Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC Project Number: **DAN005162**

Project Title: Water Smart Cotton and Grains

Project Commencement Date: 25/11/08 **Project Completion Date:** 01/11/2011

CRDC Program: Capacity Building

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1.0 Background

Irrigators want to improve their WUE in terms of bales per ML or tonnes per ML, with the intention to maximise their profitability or $/ML. An important step to achieving this is through the adoption of irrigation management best practices.

Water Smart Cotton and Grains was a water use efficiency project which aimed to improve knowledge transfer and to build capacity with the NSW Irrigated Cotton and Grains industries to adopt best irrigation practice.

It built upon the achievements of the preceding 'Knowledge Management in Irrigated Cotton and Grains' and 'Advancing Water Management in NSW' projects to further improve water use efficiency within the cotton and grains industries. It also complemented other CRDC and GRDC funded projects such as the 'High Yielding Irrigated Grains in Cotton Farming Systems' and was well aligned to the irrigation infrastructure modernisation project, sustaining the Basin: Border Rivers-Gwydir, which was led by NSW DPI.

Water Smart Cotton and Grains incorporated a comprehensive capacity building program including training workshops, technology demonstrations, consultant mentoring and dissemination of irrigation information to increase the knowledge and awareness of irrigation best practice, new irrigation technologies and to improve on-farm water management and irrigation efficiency within the Australian irrigated cotton and grains industries.

2.0 Objectives

The objectives of Water Smart Cotton and Grains are:

1) Benchmark irrigation water use efficiency in terms of bales per ML or tonnes per ML for the irrigated cotton and grains industries.

2) Increase consultants' knowledge, skills and confidence to offer a greater range of irrigation services to growers.

3) Promote and deliver irrigation training to cotton and grains irrigators and consultants to increase their knowledge of best irrigation management practice.

4) Scope the full upgrade of an Irrigated Cotton and Grains WATERpak.

5) Coordinate and/or support forums/field days/conferences to build relationships between researchers and extension staff, irrigators and consultants.

6) Benchmark irrigation water use efficiency in terms of bales per ML or tonnes per ML of low pressure overhead travelling irrigators and drip irrigation systems.

7) Demonstrate IrriSAT SMS in broad acre cotton in Northern NSW.

8) Liaise with extension, industry and regional networks to update project progress, ensure non-duplication of effort and a coordinated approach to dissemination of outcomes.

30. General Project Information

3.1 Location

The project was undertaken in the cotton and grains irrigation valleys located in NSW and Southern Qld, comprising Border Rivers/Gwydir, Namoi, Macquarie and Southern region (Lachlan & Murrumbidgee) irrigation areas.

3.2 Outcomes

The outcomes for the project

The overall outcome of this project was to improve knowledge transfer and to build capacity within the NSW Cotton and Grains Industries to adopt best irrigation practice.

1. Increased consultant and irrigator knowledge of irrigation benchmarking.
2. Irrigation benchmarks established for the irrigated cotton and grains industries in NSW and Qld.
3. Increased consultants and irrigator knowledge and skills in best irrigation practice.
4. Increased capacity of consultants to deliver irrigation services
5. Improved irrigators' adoption of best irrigation practices that improve water use efficiency.

3.3 Target Audience(s) for the research

Cotton and Grains irrigators and consultants

4.0 Methods

The following extension activities and methods were employed:

4.1 The project benchmarked irrigation water use for irrigated cotton and irrigated wheat during the 2008/09 season across Eastern Australia, using Watertrack Rapid^{TM} . Watertrack Rapid^{TM} is an on-line benchmarking tool that produces standardised and defined irrigation benchmarks which are essential for meaningful comparisons. It had also been used in a previous industry survey in 2006/07. Industry average water use indices including the Irrigation Water Use Index (IWUI), Gross Production Water Use Index, Crop Water Use Index (CWUI) along with crop yield (bales or tonnes per hectare), crop transpiration, total water used and on-farm water losses were calculated. These data have provided irrigation benchmarks for these industries to show how and at what rate improvements in water use are occurring. Individual irrigators are able to compare their performance to regional and industry averages. NSW DPI worked in collaboration with the DEEDI (formally QDPI) and CCC CRC Extension Team to survey a range of irrigators across both industries throughout NSW and Qld.

4.2 'Participatory Action Learning' was employed by working closely with consultants (including their respective clients) in an effort to encourage management change and technology adoption.

- Technology demonstrations promoting greater water measurement and water use efficiency were established in partnership with growers, consultants and industry groups.
- Farm walks and dissemination of research was conducted in association with irrigation training.

4.3 The project continued the consultant mentoring program established under the 'Knowledge Management in Irrigated Cotton and Grains' project to ensure that growers have access to a greater range of irrigation services to improve water use efficiency. Consultants had the opportunity to up-skill in a variety of irrigation services such as irrigation performance evaluation, irrigation benchmarking, metering and scheduling. Significant emphasis was placed on consultants to improve their skills in benchmarking water use efficiency.

- The project engaged at least 1 consultant from each broadacre irrigation valley in NSW. (Lachlan/Murrumbidgee, Macquarie, Namoi, Gwydir/Border Rivers) to participate in the Watertrack Rapid™ Survey

- Each consultant would collect WUE benchmarking data using Watertrack Rapid™ from at a minimum of 5 irrigated cotton and 5 irrigated wheat clients providing a larger sample population to better capture irrigation water use benchmarks for irrigated cotton and grains (wheat) during the 2008 and 2009 season in NSW.

- Each consultant was provided with training to improve their technical understanding of irrigation benchmarking. Consultants attended Watertrack Rapid™ training delivered by Aquatech Consulting and irrigation benchmarking delivered by NSW DPI.

4.4 Conduct an industry round table designed to identify gaps and revisions required for a full upgrade of WATERpak. Participants included key representatives from the grains and cotton industries.

4.5 Delivery of irrigation training (Irrigated Cotton and Grains workshop series and NSW DPI Centre Pivot and Lateral Move training courses) to both irrigated cotton and grain growers and consultants.

The Cotton and Grain Irrigation Workshop series was developed following consultation with industry through the first phase of the CRDC Project Irrigation Knowledge Management project. A key recommendation of this phase was the development of concise, detailed, practical irrigation training, targeted at a level suitable for consultants and managers. The workshops series consists of 7 workshops which cover a range of irrigation related topics including:

I. Irrigation benchmarking & budgeting
II. Scheduling I
III. Scheduling II
IV. Storage & distribution systems
V. Surface irrigation performance evaluation
VI. Pumps
VII. Metering.

These workshops were delivered in a practical and informal manner. The focus was on providing skills that can be taken away and applied. Each workshop ran for approximately 3 hours and were flexible so they could be delivered on-farm and can incorporate local trial data where required. A copy of each workshop training manual is attached to this report.

An additional workshop on Water Trading & Security developed by NSW DPI was piloted in the Border Rivers and Gwydir Valley.

4.6 Benchmark the Irrigation Water Use Index (IWUIfield) and Gross Production Water Use Index (GPWUIfield) at a field scale for lateral move, centre pivot and drip irrigation systems for cotton during the 2010/11 season and irrigated wheat grown in 2010. NSW DPI collected benchmarking information from NSW farms which was combined with benchmarking data collected in Southern Qld by Qld DERM, as part of the Healthy Head Waters Project. This provided an industry wide survey. A total of 48 farms were visited to collect input data for irrigation benchmarks. Calculations of IWUIfield and GPWUIfield were conducted using a spreadsheet based on the Irrigation Benchmarking Tool described in the WATERpak manual (Section 2.9) and referred to in myBMP.

4.7 NSW DPI worked collaboratively with CSIRO to demonstrate the Irrisat SMS technology to consultants and irrigators in the Gwydir Valley and Border Rivers. Crop Consultants had the opportunity to trial the technology over the 2010/11 season.

4.8 Innovative water related research and information on irrigation best management practices and technical advice on adoption was communicated to the cotton and grains industries via regular contributions to industry newsletters, uploading fact sheets and articles to the Irrigated Cotton and Grains website, contributing articles to industry magazines and local newspapers and through presentations at grower meetings and industry conferences. Collaborative links were established and maintained with key researchers. (eg. CSIRO, CRCIF, GRDC and National Centre for Engineering in Agriculture (NCEA)).

5.0 Monitoring and Evaluation

Water Smart Cotton and Grains included extensive monitoring and evaluation of all activities including the irrigation benchmarking survey, training workshops and the consultant support program.

All project activities were evaluated with a mix of methods. Observer sheets, evaluation sheets and dart boards were used to show changes in knowledge, attitudes, skills and aspirations (KASA) and identify practice change.

Monitoring and evaluation is essential to determine if workshops/field days were well received and also highlighted where changes could be made to improve the delivery and content of training workshops.

6.0 Results, Outputs & Outcomes

Objective 1: Benchmark irrigation water use efficiency in terms of bales per ML or tonnes per ML for the irrigated cotton and grains industries.

Output:

Industry benchmarks have been established for 2008 Irrigated Wheat and 2008/09 Irrigated Cotton. A full report is in Appendix 1, Montgomery J. & Bray S (2010). "Benchmarking water use efficiency in the cotton and grains industries", Proceedings Australian Cotton Conference, Broadbeach, August 2010.

In 2009, water use figures were collected from 46 cotton and 24 wheat farms located from Hillston in NSW to Emerald in Qld. The web-based benchmarking program Watertrack Rapid^{TM} was used to provide standardised and comparable irrigation benchmarks. Watertrack Rapid^{TM} generates a number of irrigation performance indicators such as Gross Production Water Use Index ($GPWUI_{farm}$), Irrigation Water Use Index ($IWUI_{farm}$) and Crop Water Use Index (CWUI). It also calculates seasonal crop water use and provides an estimation of on-farm water losses.

Figures 1 and 2 show the results from the 46 cotton farms and 24 wheat farms respectively, ranked by their Total Water Loss per Hectare. Each farm is in the same position for each grouping. Also shown are the Crop Yield (bales/Ha or tonnes/Ha), Total Gross Available Water (ML/Green Ha) and Crop Transpiration (ML/Green Ha).

The project aimed to have had a larger sample size for the irrigated wheat farms (minimum of 30), however the data was difficult to obtain. Much of the country had been prepared for cotton so had high nitrogen levels. A wet winter saw high vegetative growth and coupled with a wet harvest resulted in a large number of lodged crops. Many of the irrigators were reluctant to provide data, just wanting to forget the season. Others were unable to provide accurate harvested water volumes, especially where excessive rainfall had fallen.

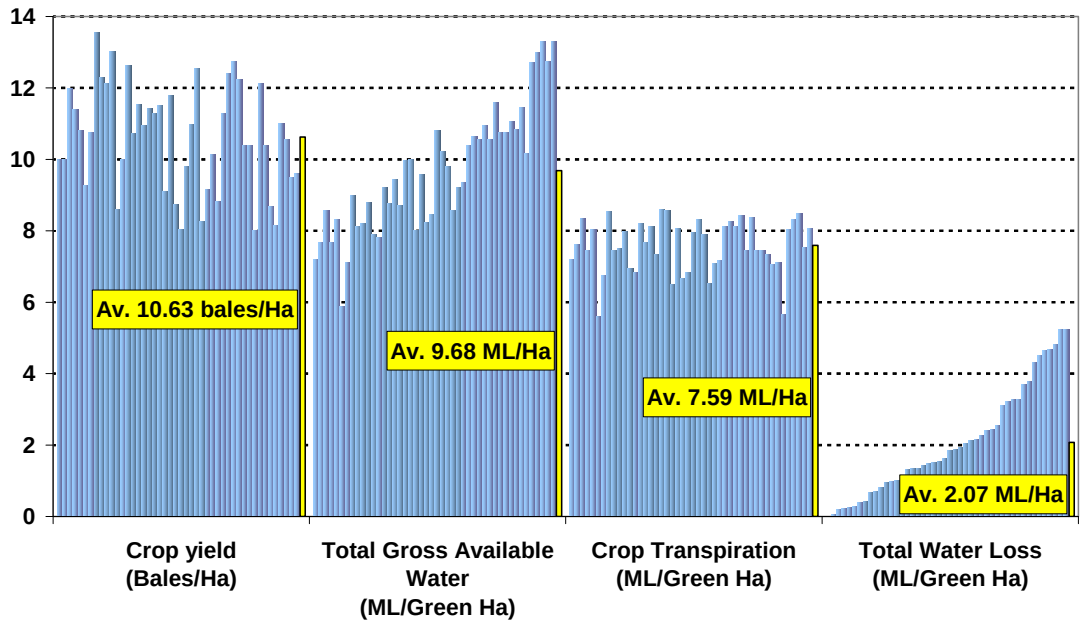


Figure 1: Variation in Total Water Loss compared to Yield, Total Gross Available Water (includes water diverted, harvested, used from storages, rainfall and soil water) and Crop Transpiration – Cotton 2008/09

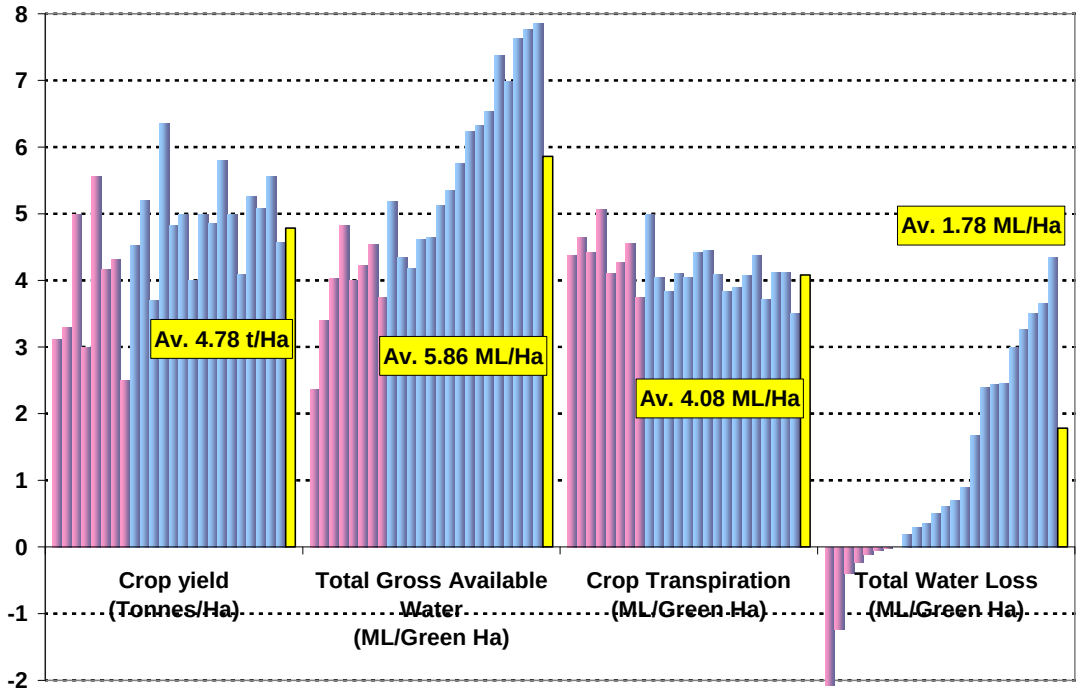


Figure 2: Variation in Total Water Loss compared to Yield, Total Gross Available Water (includes water diverted, harvested, used from storages, rainfall and soil water) and Crop Transpiration – Wheat 2008

Three water use indices, Crop Water Use Index (CWUI), Irrigation Water Use Index ($IWUI_{farm}$) and Gross Production Water Use Index ($GPWUI_{farm}$) calculated for each cotton and wheat farm are presented in Figures 3 and 4 respectively.

The survey data showed a wide range of irrigation performance and water volume estimation and measurement across the industry. It found the average $GPWUI_{farm}$ for the cotton industry was 1.14 bales per megalitre. This figure is a representative benchmark for the cotton industry for 2008/2009 and confirmed the previously revealed 40 per cent improvement by NSW DPI since the last industry estimate 10 years ago.

For irrigated wheat, this is the first industry wide data collected. It establishes an irrigation benchmark for average $GPWUI_{farm}$ of 0.85 tonnes per ML for the 2008 season.

The average $GPWUI_{farm}$ of 1.14 bales/ML and 0.85 tonnes/ML is representative of the cotton and wheat industry water use in 2008/2009. These figures that can be used to benchmark water use so industry can gauge if it is continuing to improve and determine the rate of improvement over time.

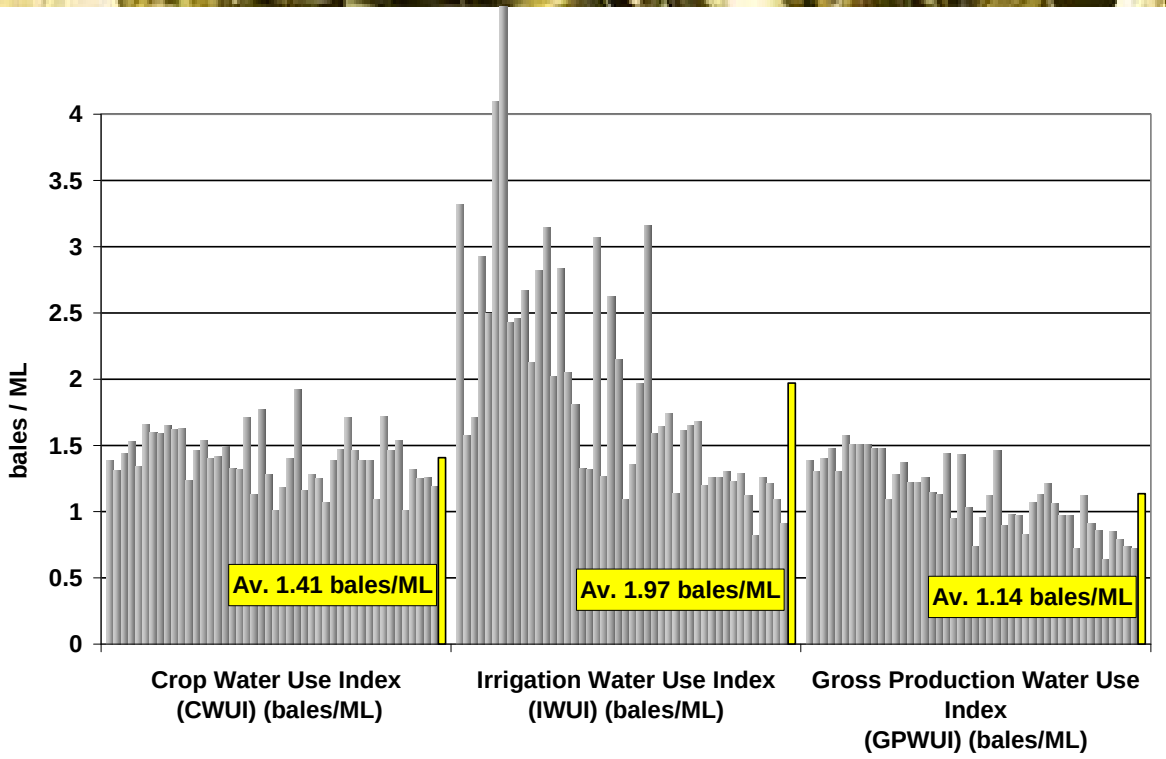


Figure 3: A Comparison of the Water Use Indices calculated using Watertrack Rapid™ - Cotton 2008/09

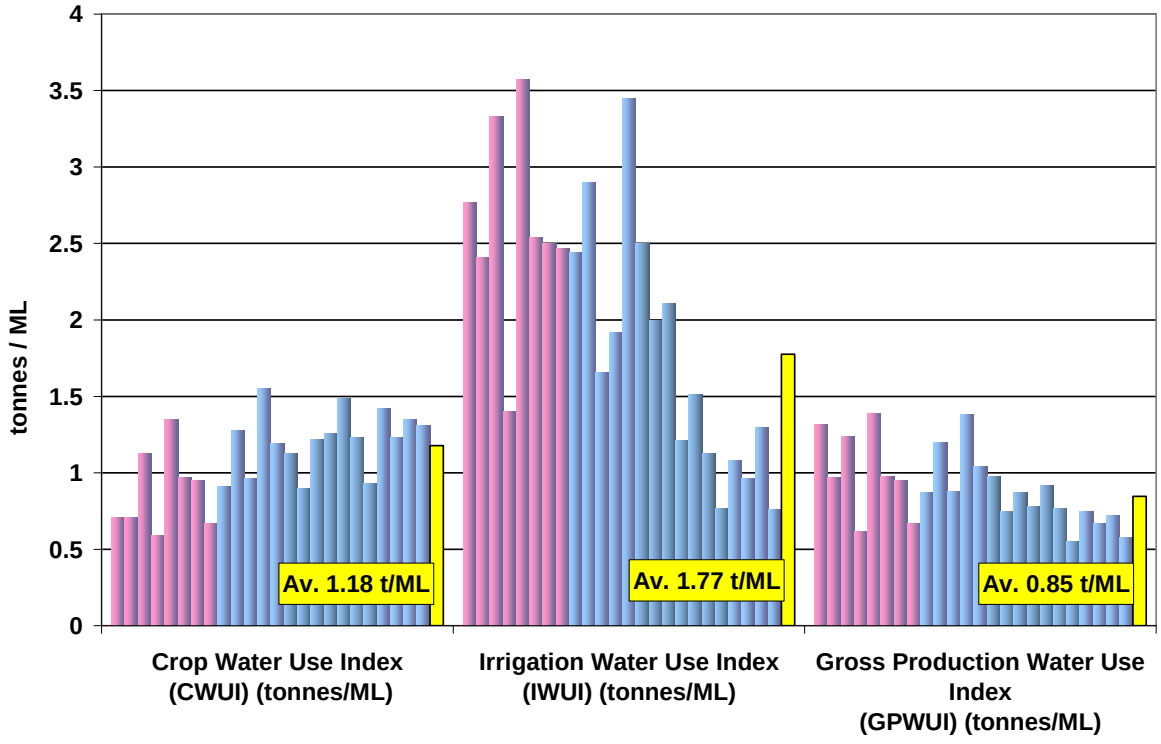


Figure 4: A Comparison of the Water Use Indices calculated using Watertrack Rapid™ – Wheat 2008

Water Smart Irrigated Cotton and Grains water use efficiency benchmarking results have been disseminated to industry at the following forums:

- ***Gwydir Valley Irrigators Association Innovation in Irrigation Field Day Nov 08***
- ***Irrigation Australia Ltd (IAL) Conference October 2009***
  Presentation: "Benchmarking Water Use Efficiency in the Australian Cotton and Grains Industries"
- ***Irrigation Australia Ltd (IAL) Conference June 2010***
  Poster Presentation: "Benchmarking Water Use Efficiency in the Australian Cotton and Grains Industries"
  - posters were exhibited for 3 days, 10 people joined a guided walk of the posters.
- ***Australian Cotton Conference August 2010***
  Poster: "Bales per Megalitre - An Industry Wide Evaluation of the 2008/09 Season"
  Hands on research sessions – "Water Use Efficiency and Comparison of Irrigation Systems".
  - Three sessions of 45 mins, in conjunction with Gwydir Valley Irrigators' Association.
  - NSW DPI provided information on the importance of irrigation benchmarking and knowing your current performance before considering an irrigation system change.
  - Results of the 2008-09 Irrigation Benchmarking Survey were presented.
  - Approximately 100 irrigators and industry personnel attended the three sessions.
- ***Western CMA Board Meeting October 2010***
- ***Cotton Production Course May 2011***
  - 45 minute WUE and benchmarking presentation delivered. Also included was what is currently being done by industry to improve water use efficiency.
- ***Various irrigation training workshops*** eg Irrigation Benchmarking, Centre Pivot and Lateral Move Training Course.
- ***Magazine and newspaper articles***

Outcomes:

Watertrack Rapid™ Irrigation Benchmarking Survey – EVALUATION MATERIAL

- 24 wheat and 46 cotton irrigators have been benchmarked in terms of yield, water use, GPWUI, IWUI and on-farm water losses.
- Growers have been interested in the results.
- Growers asked for the 0607 and 0809 survey results to compare industry and regional averages with their own farm.
- Measuring water harvested on farm is often challenging with poor water monitoring on farm. Two Gwydir irrigators who participated in the survey kept detailed water records.

Examples of water monitoring:

- One farm keeps weekly water records. They have developed a spreadsheet where storage volumes, bore readings and water pumped are recorded each Friday. These figures are the opening values for the next week and any differences are split into evaporation and crop use. Hence ability to split water between crops.

- One farmer keeps records of pumping times rather than storage volumes. He has to pump water from his storage and well as tailwater and runoff back into the storage. He records in his diary pump start and stop times.

- A number of irrigators have suggested that it would have been better to have known what data they needed prior to the season.
- Irrigators have also asked for a system of recording water volumes on farm. "Does Aquatech (Consulting) have a spreadsheet or program developed for recording water volumes over the season?" Agronomist Moree.

- One irrigator was interested in the Total Available Water and crop transpiration figures generated by Watertrack™ Rapid. "These have given me confidence in my water budgets. I have always budgeted on 8ML/ha to finish the crop and these results show I'm using the right amount"

- A Mungindi irrigator was assessing his limited water situation for the season – he used his Watertrack Rapid™ result to examine crop water use, total water applied and on farm losses to help formulate his water budget and irrigation schedules.

- Upper Namoi Irrigator. "The process was beneficial , however there were some assumptions made, such as using weather data from quite some distance from the crop location, in our case several kilometres."

- Lower Namoi irrigator. "I didn't get a lot out of it .Although it was interesting to be able to compare my yield with other growers. I think as an industry we do need to take into consideration rainfall, soil moisture, as well as irrigation water applied to the crop to make it consistent"

- Consultant from the Upper Namoi. "Watertrack Rapid™ is easy to use, good relevant data. A program I wouldn't see being used every year. If I could I would pay two to three thousand to buy the program and use with my clients, every two years or when I see a problem. A valuable tool to work out dollars per megalitre when working out a gross margin on what crop has the most earning capacity , in comparing returns per ML between the different crops on an annual basis "

- Project Officer, Stuart Bray, who delivered the program for irrigators in Emerald, Dalby, the upper and lower Namoi and the Macquarie.
"One observation was the large variation between growers from QLD to the central west in the way they presented their water keeping records and the suspected accuracy of those records. Some irrigators had very good records of what was pumped onto farm, but not so good on what was held in storage through the season, where it went, how much, and when."

"I felt some irrigators just wanted to match up water pumped onto farm, to water applied, and felt some were doing this in their heads, without taking into consideration evaporation losses, transmission losses, and deep drainage"

"One of the big pluses was being able on occasion to identify serious structural faults causing water loss. One irrigator wasn't surprised when I showed him the report that indicated that he was losing several hundred megalitres from when he pumped water into his storage to when he applied it to the crop. When he saw the report he said " Ah yes we have just had the Storage tested for seepage losses and one end of it is sited on top of a gravel seam, so we now know that we are losing a lot there!"

The good news is that this is now being repaired. However the Watertrack Rapid™ program showed that there was a problem.

"Irrigators always had accurate figures for irrigation dates, if all the other records of water pumped around the farm and onto other crops were as good, it would take very little time to complete a report and see if there were any issues with water management."

The Water Smart Cotton and Grains project has followed on from the initial work concerning irrigation benchmarking conducted by the Qld Rural Water Use Efficiency projects, NSW

Advancing Water Management and the Knowledge Management in Irrigated Cotton and Grains projects. It appears that the Australian Cotton Industry now has a good understanding of the water use indices IWUI and GPWUI, how to calculate them and how to use them for meaningful comparison.

The grains industry has been calculating crop water use efficiency in terms of kg/mm/ha, however, this was the first industry wide data looking specifically at irrigated wheat production and the associated water use indices. It is well known that irrigated grains are competing with other irrigated crops such as cotton for water. There was a lot of interest in growing irrigated wheat at the start of the Water Smart Cotton and Grains project in 2008, when cotton prices and plantings were at a record low. More recently the profitability of irrigated cotton production is outstripping irrigated grains and the area planted to grain crops for irrigation is very much reduced, impacting on survey sample size. However, no matter what the size of the industry there is pressure to use water wisely and the irrigation benchmarks established in this project can be used for comparisons into the future.

Objective 2: Improve irrigated cotton and grains consultants' knowledge of a range of irrigation services.

- *Engage one cotton/grains consultant in each region per year.*
- *Provide support and training in the irrigation service identified as a need by the consultant*

Outputs & Outcomes

Thirty irrigation and crop consultants had the opportunity to increase their skills in a range of irrigation technologies including irrigation benchmarking, soil moisture monitoring, irrigation scheduling and IrriSAT technology. Twelve of these consultants were engaged to collect irrigation benchmarking data from their clients. The consultants attended Watertrack Rapid™ and irrigation benchmarking training. Five Irrigation Officers with NSW DPI were also trained in Watertrack Rapid™ and participated in the collection of irrigation benchmarking data.

A list of consultants and the irrigation topic where they were provided training and support by NSW DPI Irrigation Officers is given below:

Darling Downs

- Neil Robertson, MCA Consulting
  - Watertrack Rapid™.
- Jessica Ulm, WaterBiz
  - Watertrack Rapid™, Irrigation Benchmarking, Metering

Border Rivers

- Simon Dunlop, B&W Rural,
  - Watertrack Rapid™, Irrigation Benchmarking, Metering
- Frank Valentine, MCA Consulting
  - Watertrack Rapid™, Irrigation Benchmarking, Metering
- Ben Muller, FSA Consulting
  - Mace Flow Meters
- Garry Campbell, Water Dynamics
  - On–farm WUE assessments
- Pablo Vega
  - IrriSAT

St George/Dirranbandi

- Justin Schultz, WaterBiz
  - Watertrack Rapid™, irrigation benchmarking, metering, on–farm WUE assessments, pump efficiency

Justin Schultz, Irrigation Consultant, WaterBiz
Pump efficiency training, irrigation benchmarking, Watertrack Rapid™
Justin Schultz is an irrigation consultant with "WaterBiz", based in St George. Justin had just moved to St George when he signed up to collect Benchmarking Data for the Watertrack Rapid Benchmarking Survey. He was very enthusiastic to collect this information and it also gave him the opportunity to introduce himself and the irrigation services within his business to irrigators in the region. Although Justin did not adopt Watertrack Rapid™, he understands the need to collect standardised benchmarks. He has since developed his own spreadsheet for benchmarking irrigation performance and formed an irrigation benchmarking group.

Justin attended the "Train-the-trainer" for the Pump Workshop. He already had good skills in pump fundamentals and examining pump efficiency, so the course acted as a refresher. However he has been able to assist in the delivery of this course in Qld.

- Dallas King, BAC
  - pump efficiency
  - IrriSAT

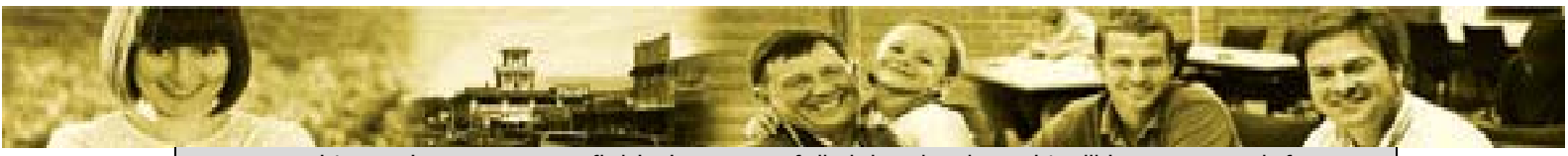
Gwydir Valley

- John Doble, Gwydir Valley Irrigators Association
  - Irrimate™, metering, soil moisture measurement, mace flow meter training, irrigation benchmarking, Watertrack rapid™, on–farm WUE assessments, on-farm storage meters and mace flow meter.

John Doble, GVIA
Outcomes - Narrative
John Doble was employed by Gwydir Valley Irrigators Association to run the Irrigation Systems Trial at Keytah, Moree. NSW DPI assisted John to up skill in a number areas concerning water management. He was provided training in Irrimate™ and surface irrigation performance evaluation. He was shown how to measure starting and ending soil moisture using an hydraulic corer, handling soil samples and methods to calculate gravimetric and volumetric water content. He attended a variety of irrigation training workshops including irrigation benchmarking and metering. As a result he was able to calculate water use indices for each of the irrigation systems within his trial.

- Ben Dawson, B&W Rural
  - Watertrack Rapid™, Irrigation Benchmarking, Metering
- Rob Holmes, HMAg
  - on-farm storage meters,
  - IrriSAT

Storage Meter Demonstration, Rob Holmes (HMAg) & Garry Lee's (Manager South Bunarba, Weemelah)
Outcomes - Narratives
"I never really knew how much water this storage held"
"The storage meter has been invaluable this season. By installing the storage meter, I had to get the storage surveyed, something I have been meaning to do for some time.
"The storage capacity information enabled me to confidently develop water budgets for this season's cotton crop. Early on, when storage volumes were low, I could calculate how much irrigation water I would have for the crop and manage it accordingly. Thankfully rain



came and I now know we can finish the crop - fully irrigating it and I will have water left over."
"I've used it to check on irrigation water use during an irrigation event as well."

Irrigation Benchmarking, IrriSAT SMS, Rob Holmes (HMAg)
Outcomes – Narratives
Rob Holmes
The greatest use I have for using IrriSAT ETc information is for benchmarking my clients' cotton crops.

When I'm calculating the crop water use index I need a reliable estimate of ETc. The IrriSAT technology has provided me with this. Its quick and easily obtained for my end of season benchmarks. It reflects the whole paddock, rather than just a single square metre of the paddock.

Benchmarking crop water use allows me to look back over the season with my clients and compare crop productivity in terms of water use between fields and farms. We can discuss what might be occurring in field such as compaction, what areas are performing well, etc and try to improve over time.

- Charlie McFarlane/Andrew Vanderstok, Irritek
  - Mace Flow Meters, on–farm WUE assessments
- Nathaniel Phyllis, Contract Irrigator
  - Mace Flow Meters, Irrigation Benchmarking
- Nick Gillingham, Sundown Pastoral Co.
  - IrriSAT, MACE Flow Meters
- Sean Boland and Owen Berry, Auscott
  - IrriSAT, Irrigation Benchmarking
- Lindsay Tuart
  - IrriSAT
- Mike Stone
  - IrriSAT, Surface Irrigation & SISCO
- Megan Hamilton, B&W Rural
  - IrriSAT
- Terry Gould, Landmark
  - Centre pivot performance evaluation, irrigation benchmarking, irrigation scheduling.

Namoi Valley

- Mitch Carter, AIMS
  - Technical/network support when required, on–farm WUE assessments, Panametric meter training

Panametric Flow Meter Training, Mitch Carter, Irrigation Consultant, AIMS
Loaned NSW DPI Panametric flow meter to check and calibrate flow rates from bores, pump sites and overhead irrigation systems.
Outcomes - Narratives
On one farm, AIMS Consultancy used the Panametric water flow meter to measure bore flow rates. Variance from the actual bore meters and the Panametric ranged from 4-7%. This was brought to the attention of the irrigator and adjustments have now been made in developing water budgets.

On another farm one of the bores had dropped off in flow rate by 19% from records 7 years ago suggesting pump wear as surrounding bores were still producing at the same levels suggesting the aquifer had adequately recharged. In response the irrigator has investigated options to refurbish the bore to return it to original yield levels.

- Russell Ison
  - Watertrack Rapid™ training, metering, irrigation benchmarking

Russell Ison, Agribusiness Consultant Carroll, Irrigation Benchmarking
Narrative:
"This work helps consultants like myself make better decisions, which in turn benefits the productivity of growers. Farmers are notoriously poor self-evaluators (as a farmer's son I realise this first-hand). Benchmarking is a difficult concept to get across, but it does lead to better practice. This work also shows the broader community we are actively improving all the time. Perhaps you are preaching to the converted but I say keep it up."

- Lew Hyson
  - On–farm WUE assessments
- Jim Purcell
  - On–farm WUE assessments

Macquarie Valley

- Matt Ceeney, Agronomic Business Solutions
  - Watertrack Rapid™, irrigation benchmarking, Centre Pivot Lateral Move National Training Course
- Campbell Muldoon, CRM Agricultural Services
  - Centre Pivot Lateral Move National Training Course
- Warwick Harrison, CRM Agricultural Services
  - Watertrack Rapid™, irrigation benchmarking

Southern NSW

- Paul Hudson, Cropsol
  - On-farm storage evaporation & seepage assessment

Darling Downs

- Neil Robertson (MCA)
  - Watertrack Rapid™, irrigation benchmarking, metering

Watertrack Rapid™ Training

Two training workshops were held for 12 consultants that were engaged to collect irrigation benchmarking data from their clients.

10th June 2009 – Consultants Irrigation training day

- 10 consultants and 6 irrigation extension officers attended the following training:
  - Irrigation benchmarking
  - Watertrack Rapid™
  - Metering
- The cotton and grains consultants came from Goondiwindi, Mungindi, Moree and Gunnedah

Outcomes:

- Increased awareness and promotion of best irrigation management practice to improve water use
- Increased knowledge of irrigation benchmarking on-farm
- Improved understanding of the term Water Use Efficiency
- Increased ability to calculate and compare irrigation benchmarks
- Ability to use Watertrack Rapid™ to calculate on–farm water losses and a range of water use indices.

Watertrack Rapid™ Workshop Evaluation

To what extent do you understand the process of determining WUE?
All participants had an improved understanding, with 5 participants recording a change from medium to high.

How likely are you to benchmark water use efficiency now you have completed this benchmarking and Watertrack Rapid™ training?
Three consultants already benchmark irrigation WUE using either Watertrack Rapid™ or they use their own spreadsheet.
Seven consultants are likely to start benchmarking as a result of this training.

10th August 2009, Consultants Watertrack Rapid™ Training Day, Warren

- 2 agronomic consultants and 1 cotton extension officer and 1 irrigation extension officer attended this training.

  Outcomes:

  - Increased awareness and promotion of` best irrigation management practice to improve water use
  - Increased knowledge of irrigation benchmarking on-farm
  - Increased ability to calculate and compare irrigation benchmarks
  - Ability to use Watertrack Rapid™ to calculate on–farm water losses and a range of water use indices.

Watertrack Rapid™ Workshop Evaluation

The two consultants indicated interest in helping with the benchmarking project. However, one consultant had only one irrigated cotton client in 08-09 and no irrigated wheat in 2008.

Irrigation benchmarking data collected industry wide provides important industry data to show how and at what rate the industry is improving in terms of water use efficiency. In the current political climate, which includes significant water reforms, the Australian Cotton Industry has been proactive in the collection of water use data. The industry can see the value of collecting this data over time and had envisaged that this data be collected by consultants as a commercial service. The Water Smart Cotton and Grains Project was to be the catalyst to promote and presumably result in the adoption of new benchmarking tools, such as Watertrack Rapid™, by local crop and irrigation consultants.

Twelve consultants were engaged to collect irrigation benchmarking data using Watertrack Rapid™. The consultants' initial interest in the project was high and was displayed by their eagerness to come along to training as shown in the numbers attending. By participating in the benchmarking survey, consultants had the opportunity to improve their skills in irrigation benchmarking and trial Watertrack Rapid™ for up to 10 farms each. This would give the consultants time to assess the benchmarking tool, understand the time involved and gauge the benefits for their consulting business.

Unfortunately after training the consultants interest in participating in the survey waned. From the twelve consultants who were trained to use Watertrack Rapid™ and attended

irrigation benchmarking training, only 1 actively collected data (from 7 farms), while 2 collected data from just one farm each and 5 provided names and contact details for potential participants.

A phone survey was conducted to collect information as to why the interest dropped. This survey indicated that although the consultants thought the Watertrack Rapid™ program was quite good, easy to use with good information for their clients, they could not justify the time involved in collecting the data, particularly since they did not receive any payment for their time. The results of the phone survey are provided in Appendix 2.

Ten of the consultants were agronomic consultants, rather than irrigation consultants. This made a significant difference in their commitment to data collection. The agronomic consultants were faced with timely decisions in terms of nutrition, pest and disease and weed control decisions. These activities took precedence over water management activities such as collecting irrigation benchmarking information.

Although the consultants did not adopt the Watertrack Rapid™ technology, two of the consultants have developed their own irrigation benchmarking tools, one of which is based on the WATERpak manual's irrigation benchmarking spreadsheet. One consultant has formed an irrigation benchmarking group with his clients, while the other provides irrigation benchmarks in his crop reports and is able to compare field and farms within his client base.

Objective 3: Promote and deliver irrigation training to cotton and grains irrigators and consultants to improve awareness of best irrigation management practice

- Promote and deliver 2 irrigation workshops per region per year to cotton and grains irrigators and consultants
- Increase cotton and grains irrigators and consultant's knowledge of best irrigation management practices.

Outputs:

Irrigation training is a key activity contributing to the capacity building of irrigators and consultants resulting in the adoption of best management practice.

Training was promoted through grower meetings, phone calls to individuals and a range of magazine and newspaper articles.

A total of 35 training events have been delivered to 436 participants including 253 cotton and grains irrigators and 125 consultants, 18 irrigation retailers and 40 industry personnel (agribusiness, extension services) located from southern NSW to southern Qld. A summary of training events delivered by NSW DPI for cotton and grains irrigators and consultants is presented in the Table 2. A detailed breakdown of these workshops is provided in Appendix 3.

Outcomes:

Irrigation training delivered to cotton and grains irrigators has resulted in various outcomes, including:

- Increased awareness and promotion of best irrigation management practice to improve water management on-farm.
- Increased understanding of overhead irrigation system operation and management as a result of attending the workshop.

- Increased understanding of the need to conduct performance evaluations of overhead irrigation systems.
- Increased knowledge of irrigation benchmarking on-farm
- Improved understanding of the definition of Water Use Efficiency and the associated water use indices and system efficiencies.
- Increased ability to calculate and compare irrigation benchmarks
- Ability to use Watertrack Rapid^{TM} to calculate on–farm water losses and a range of water use indices.
- Increased understanding of the need for metering, basic flow hydraulics, meter types, installation and maintenance.

TABLE 2: Training Workshops delivered during the Water Smart Cotton and Grains Project

Training Workshop	No. of Workshops	Irrigator	Retailer	Agronomic Consultant	Irrigation Consultant	Industry	Total
Irrigation Benchmarking	5	13	0	9	9	1	**32**
Irrigation Scheduling	2	4	0	7	0	3	**14**
Irrigation Pumps	1	0	0	0	3	0	**3**
Surface Irrigation Performance Evaluation	1	3	0	0	3	1	**7**
Centre Pivot and Lateral Move	7	90	6	0	4	2	**102**
Watertrack Rapid™	2	0	0	10	2	0	**12**
Water Metering	2	5	0	11	4	0	**20**
Water trading and Security	2	22	0	0	0	9	**31**
Storage and distribution systems	1	9	0	0	2	1	**12**
Irrigation Technologies	5	37	1	24	20	17	**99**
Drip Irrigation	3	28	11	0	1	0	**40**
On-farm WUE Assessment	1	0	0	0	14	0	**14**
GroundWater Monitoring and Management Workshop	2	23	0	0	0	6	**29**
Cotton Production Course – Irrigation Management and WUE	1	19	0	2	0	0	**21**
TOTAL	**35**	**253**	**18**	**63**	**62**	**40**	**436**

Evaluation material captured during training events showed how training resulted in changes to knowledge, aspirations, skills and attitudes towards irrigation best practice.

Significant evaluation material was collected as part of the Sustaining the Basin Border Rivers-Gwydir pilot project which ran for 12 months from October 2009. Thirteen training workshops were attended by a total of 176 irrigators/consultants and industry personnel in the Border Rivers-Gwydir region. They found 87 per cent of irrigators that attended training improved their understanding of best irrigation practice to improve on-farm WUE (Figure 5). These evaluation data provide evidence of increased understanding of best irrigation management practice within the irrigated cotton and grains industries.

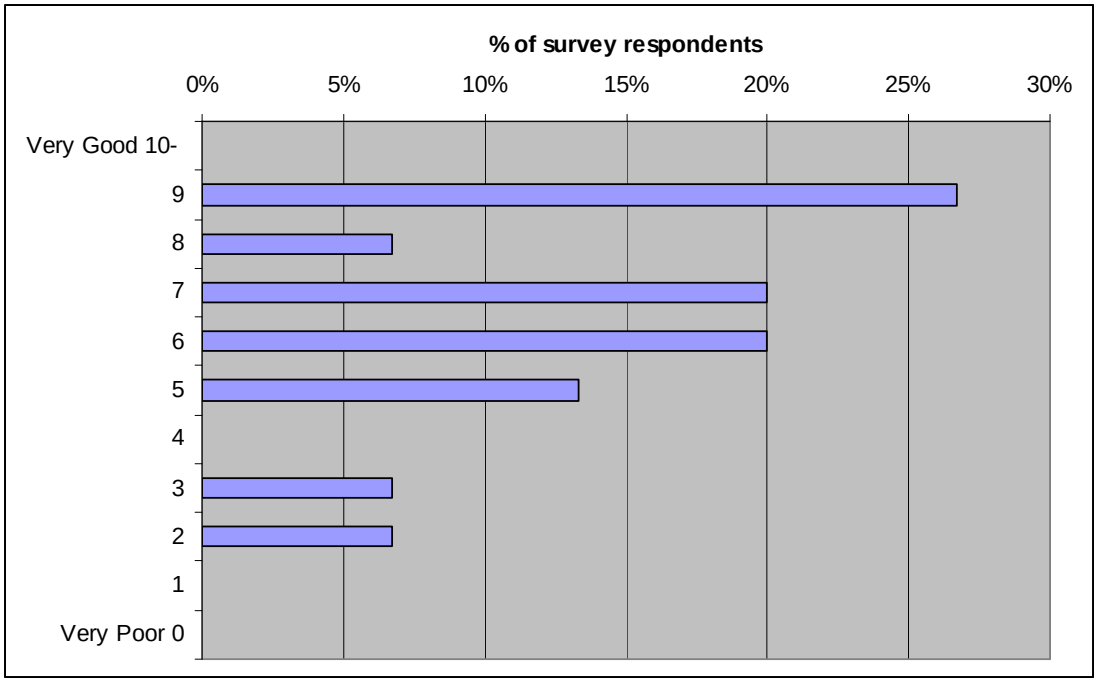


Figure 5 STBBRG Training Evaluation, 13 irrigation workshops conducted from Jan – Oct 2010. Summary of responses from: Please rate how the training offered improved your understanding in Best Irrigation Management practice to improve water use efficiency on farm

Further examples of practice change and adoption of best irrigation practice as a result of attending irrigation training are presented below.

Evaluation of Scheduling Workshop 01/12/08:
Dart Board:
Q1: How do you rate your understanding of Scheduling?
Before: 0 high, 1 Medium, 4 Low, 0 very low
After: 0 High, 5 Medium, 0 low, 0 very low.
All participants had an increased understanding of irrigation scheduling as a result of attending the workshop.

Q2: How important do you think irrigation scheduling is?
Before: 1 high, 4 Medium, 0 Low

After: 5 high, 0 medium, 0 Low. All participants had increased their position of importance on the evaluation dartboard, moving closer to the "bulls eye"

After the workshop, participants were also asked if they would use parts of the scheduling process in future management:
4 said they would use parts of the process in future management

Evaluation of Metering 01/09/2009
To what extent do you understand basic flow hydraulics and their impact on metering?
Before the workshop: 7 low, 2 medium and 1 high.
After workshop: 5 medium and 5 high.

To what extent do you understand the importance of installation for metering?
Before workshop: 1 Low, 6 Medium and 2 high responses.
After workshop: 2 medium and 8 high responses.

Evaluation of Benchmarking Workshop 01/07/2010

You-Tube Video's developed by Stuart Bray, NSW DPI
Sean Boland, Auscott - Irrigators Perspective on Benchmarking

Nathanial Phillis, Keytah - Irrigators perspective on improving on farm water measurements

Evaluation of Mace Meter Training 09/06 2009
All participants thanked me for the opportunity to gain training from MACE.
"I have had a lot of questions answered here today"
"I feel more confident about using mace meters in the field'
One farm manager began negotiations with MACE to design a metering system at a major pumping station on farm, where water is both released from and returned to the on-farm storage along with metering diesel fuel consumption of the pump engines at this site.

Evaluation CPLM Performance Evaluation Farm Walk 07/09/2009
As a result of the CP evaluation conducted by NSWDII staff:
The owner has instructed his consultant to commence audits on all of the property's 8 new centre pivot travelling irrigators currently servicing 333Ha with a 2700ML water entitlement. These machines represent an investment in excess of $1m. The owner intends to forward the cost of the auditing to the manufacturer and dealer.

Other irrigators who attended and witnessed first hand the issues and problems associated with purchasing large travelling irrigators are investigating their options to either test their CP machines themselves or have their machines tested by a professional.

Questions were asked regarding the energy use efficiency of lateral move and drip irrigation systems compared to furrow irrigation.

Evaluation of Storage and distribution Workshop 17/03/2010
90% of participants indicated the course met their expectations and was presented at a high standard.
As a result of attending the workshop:
90% of participants increased their level of knowledge and skill on the management of on-farm
90% of participants increased their level of knowledge of measuring the efficiency of their on farm storage

90% of participants increased their knowledge and skill on the management of supply & tail water systems
90% of participants increased their rating on the importance of regularly monitoring water volumes on-farm
70% of participants increased their rating on the importance of a storage volume survey
90% of participants increased their rating on the importance of a storage seepage/evaporation evaluation

Evaluation Drip Irrigation Workshop 18/08/2010
There was considerable evidence gathered showing an improvement in knowledge in planning and managing drip systems as a result of attending the workshops. This is supported by irrigator comments when asked the following questions:

If you are thinking of installing a drip irrigation system, what changes, if any, to your system are you now considering as a result of this workshop? Typical responses were:

"Make sure you get good advice, design and planning"
"Know your system design and output"
"Making sure preventative maintenance is spot on"

If you already have a drip irrigation system, what if any changes will you make to the management of your drip system within the next six months and the next two to four years as a result of this workshop?

"Modify and better record flushing system"
"Better maintenance schedule"
"Measure pressures, outputs (flow rates) and flushing"
"Measuring flow rates and pressures more accurately"
"Flushing more often".

You-Tube Video's developed by Stuart Bray, NSW DPI
David Reibel, Stahmann Farms - Converting flood irrigation to drip
George Gibson, Trangie - Irrigators perspective on broad acre drip irrigation

Detailed evaluation of all the workshops capturing KASA changes is provided in Appendix 4.

Objective 4: Scope the full upgrade of WATERpak

WATERpak is a manual of Best Practice Irrigation Management for Irrigated Cotton and Grains. Although originally developed for the Australian Cotton Industry, collaboration with the grains industry in a variety of projects led to the inclusion of some irrigated grains information in 2008.

Background:
In 2002 information on irrigated management of cotton was limited to one AgFact and a number of reports.
"We needed to flush out all irrigation information and make it available to the cotton extension team and others. At that time there were a lot of new entrants in the industry and it was seen to be a useful document" Guy Roth.
The 1st Edition of the WATERpak Manual was published in 2003. As part of the Knowledge Management in Irrigated Cotton and Grains project, the WATERpak manual was supplemented with Irrigated Grains information in 2008. A recommendation of this project

was that the entire manual should be revised and the range of industries and commodities broadened, so that it becomes a suitable national reference.

Output:
An industry roundtable to scope the upgrade of cotton and grains WATERpak was held in Moree 18/03/2010.

As part of the Water Smart Cotton and Grains project, NSW DPI coordinated a review of the WATERpak manual. Fourteen cotton and grains representatives met to review current Waterpak and identify gaps and new information required for a full upgrade of WATERpak to include both irrigated cotton and grains management information.

Present: Mike Bange (CSIRO), Rose Broderick (CSIRO), Helen Dugdale (CRDC), Nick Gillingham (Sundown Pastoral Co.), Graham Harris (DEEDI), Rob Holmes (HMAg), Rod Jackson (NSW DPI), David Larsen (CCC CRC), Peter McKenzie (AgVance), Janelle Montgomery (NSW DPI), Allan Peake (DEEDI), Guy Roth (NPSI), Peter Smith (NSW DPI), David Wigginton (CCC CRC)

Apologies: Peter Birch (B&W Rural), Tom McCue (GRDC), James Clark (GRDC), Brendan Griffiths (Griffiths Ag), Stuart Kearns (GRDC), John Lacy (NSW DPI)

The purpose of the Cotton and Grains WATERpak was discussed at the meeting and it was agreed that the Cotton and Grains WATERpak will provide a knowledge bank of Australian cotton and grains irrigation and water management information. Importantly it will provide an avenue for quality control of Australian cotton and grains irrigation information to ensure irrigators receive credible information which they can easily access and use with confidence.

An upgrade of the Cotton and Grains WATERpak is required for the following reasons:

1. New research: The cotton information was published in 2003, while the grains supplements were published in 2008. Significant research has taken place since and needs to be included in the new manual.
2. Quality control: Industry provide quality control of the information contained in the manual during its development and therefore the information in WATERpak is credible and trusted by users
3. Accessibility: Irrigation information needs to be readily available through a number of avenues to suit the user. Although the original WATERpak manual was distributed by hardcopy, it has since been available on CD. Registrations are required so updates can be mailed out when available. The manual is also available electronically on the Cotton Community Catchments Website.
4. Extension and Education (myBMP): The manual is a key irrigation extension and education resource used widely by industry extension officers. It is also a significant resource for water and irrigation information for myBMP.

Current Usage:
The meeting participants discussed their uses of WATERpak. Their responses are given below:

Rob Holmes (Consultant): *"I use it, its credible, providing information specific to the Australian Cotton Industry, not commercial. My growers are generally aware of it. Sometimes they will ask for*

clarification about an irrigation topic. I use the info in WATERpak as backup, that is when I send a grower a report – I say this is what I think and this is what WATERpak says."

Mike Bange (Researcher) – *"I would have used it 10 times over the summer for enquiries from growers. I can just refer then to chapter XX in WATERpak. There are also a lot of users outside of the Industry. Particularly for certain chapters eg Chapter 2.2: Water Use Efficiency in the Australian Cotton Industry"*

Peter McKenzie (Consultant): *"I have used it from the Website. Grains growers haven't used it. Brilliant source of information – quick, easy, in one place – Australian Industry Data, credible information which is essential*".

Nick Gillingham (Consultant): Doesn't use WATERpak. Uses industry people, CRC website, own networks for information. Pretty comfortable with water management.

Peter Smith (Extension Officer), made comment that Ben Stephens (Auscott Narrabri, at the time) had said *"this is my one-stop shop for Cotton Water Management and irrigation information"*

David Wigginton (Extension Officer): "*Extension Officers regularly use information from WATERpak in extension activities. They develop fact sheets and hand outs based on information from WATERpak and use during extension activities eg siphon flow charts*".

Guy Roth (Irrigation Industry Representative): "*University Students use it too, but the main users have been mentioned. Water policy people are important users of the information in both state and federal agencies. The industry needs a forum to convey messages that its water management is cutting edge"*.

Graham Harris (Irrigation Extension Specialist): "*Its an important resource for myBMP"*

David Larsen:

- Current Registrations for WATERpak (hard copy):
    - 2004: 386 registrations,
    - 2005: 420 registrations(which does not include 52 copies that were distributed but recipients have since left the industry,
    - Jan 2010: 315 registrations.
    - Total of 500 WATERpak manuals distributed with 315 current registrations

- Current Registrations for WATERpak (CD version): 456 of which 128 are common with WATERpak hard copy registrations.

WATERpak is also available on the Cotton CRC Web site. David Larsen can record number of hits on the WATERpak page since December 2007 and track the number of hits on individual chapters. However figures will be underestimated as it does not account for hits on chapters that come directly from search engines or direct links from other websites.

Outcome:

An outline of the new Cotton and Grains WATERpak Manual was developed along with suggestions on future publication. This outline will go to CRDC/GRDC where it is hoped funding will be provided for a future project to coordinate and complete the Cotton and Grains WATERpak upgrade.

The WATERpak outline is provided in Appendix 5.

Objective 5: Coordinate and/or support forums/field days/conferences to build working relationships between researchers and extension staff, irrigators and consultants

Outputs:

NSW DPI staff have organised and supported a range of field days, industry forums and meetings, technology demonstrations and conferences as shown in Table 3. This has ensured networks with key irrigation researchers were maintained and extension of the latest irrigation research continued.

Table 3: Number of field days, industry meetings and technology demonstrations

Activity	Number
Field Day and Industry Forum Presentations	24
Industry Meetings	39
Technology Demonstrations	4

A wide variety of irrigation publications have also been produced during the life of the Water Smart Cotton and Grains project. A summary is presented in Table 4.

Table 4: Publications

Activity	Number
Ground Cover	1
Agriculture Today	16
Cotton and Grains Outlook	1
Australian Cotton Grower	24
CRDC Spotlight	6
Conference Proceedings	7
Irrigation Journal	1
IREC	4
Local Newspapers	7
Cotton Tales	9
Irrigation Videos	15
Website Articles	13
TOTAL	**104**

A detailed list of field days and presentations, industry meetings and publications are provided in Appendix 6.

Objective 6: Benchmark irrigation water use efficiency in terms of bales per ML or tonnes per ML of low pressure overhead travelling irrigators and drip irrigation systems.

- *Identify water use efficiency indices in terms of bales per ML or tonnes per ML for cotton and grains grown under centre pivot, lateral move or drip irrigation systems.*
- *Benchmark Cotton for 2010-11season and irrigated wheat for 2010 grown under overhead irrigation.*

Outputs and Outcomes:

48 farms were visited to collect irrigation benchmarking data from lateral move, centre pivot and drip irrigation systems. The project had planned to benchmark both irrigated wheat and irrigated cotton, however we were only able to collect data from 3 wheat fields and consequently the project has not been able to meet this objective. We found it difficult to find irrigators that produced irrigated wheat under these irrigation systems during 2010, and the few that did were often unwilling to provide irrigation data for their wheat crop for a variety of reasons. Irrigated wheat production was low during 2010, as the cotton price had bounced back (>$500/bale) and many irrigators were holding their water for a more profitable cotton crop. Qld DERM collected data from 31 irrigators with 31 CP or LM systems. There was no irrigated wheat, only 2 maize, 2 beans and 1 lucerne crop benchmarked, the remainder were cotton. A summary of the data collected for the irrigated grain crops is provided in Table 5.

The 45 cotton fields benchmarked included 21 lateral move irrigation systems, 19 centre pivots and 5 drip irrigation systems. A summary of crop yield, irrigation water applied and seasonal water usage for each irrigation system is given in Table 6. There was wide variation in all three systems for all three variables.

The average yield for cotton grown under the lateral move irrigation systems was 9.93 bales/Ha. The yield for the cotton grown under a centre pivot was slightly lower at 9.47 bales/Ha. Both these yields are higher than the industry average yield reported by Cotton Australia for the 2010/11 crop of 8.78 bales/Ha. The range in megalitres per hectare of irrigation water applied varied between farms, depending largely on the amount of in-crop rainfall. On average, close to 3ML/Ha of irrigation water was applied for both the lateral move and centre pivot irrigation systems. The irrigation water applied and seasonal water usage under the 5 drip systems appears questionable. The average amount of irrigation water applied under the drip irrigation systems was 6.32 ML/Ha, which is double that applied to crops under the Centre Pivot and Lateral Move irrigation systems.

The irrigation benchmarks for lateral move and centre pivot irrigation systems for cotton in 2011/12 are presented in Table 7. The sample size for drip, at only 5 farms is too small to provide a useful industry average.

The average Irrigation Water Use Index ($IWUI_{field}$) was 5.09 b/ML for the lateral move systems and 3.41 b/ML for the centre pivots. When all water sources are accounted, including irrigation, effective rainfall and soil moisture, the average Gross Production Water Use Index ($GPWUI_{field,\ effective}$) was 1.4 bales/ML for cotton produced under lateral move machines and 1.33 bales/ML for the centre pivots.

Figures 6 to 8 show the results for each individual farm for the Lateral Move, Centre Pivot and Drip Irrigation system respectively, and they clearly show the variation between farms. Good performance of these irrigation systems depends largely on management.

Table: 5: Water use indices calculated for irrigated grain crops

Farm	1	2	3	4	5	6	7	8
Irrigation System	DRIP	Lateral Move	Lateral Move	Centre Pivot	Centre Pivot	Centre Pivot	Centre Pivot	Centre Pivot
Production details	**Wheat**	**Wheat**	**Wheat**	**Beans**	**Beans**	**Lucerne**	**Maize**	**Maize**
Area grown (ha)	12	124	125	208	38	51	30	73
Average Yield (t/ha)	4.51	3.77	3.84	1.00	1.25	7.25	14.00	14.25
Total irrigation applied on cotton (ML/Ha)	0.80	0.80	0.80	0.15	0.60	2.31	1.36	2.97
Irrigation Water Use Index (field) (t/ML)	**5.64**	**4.71**	**4.80**	**6.67**	**2.08**	**3.14**	**10.29**	**4.80**
Soil Water Used soil reserve (ML/Ha)	0.45	0.60	0.60	0.24	1.32	0.39	0.67	0.00
Total in-season rain (ML/Ha)	2.45	2.45	2.45	6.76	16.34	8.45	10.59	1.47
Seasonal water usage (total, total rainfall) (ML/Ha)	3.70	3.85	3.85	6.67	15.63	11.15	12.61	4.44
Gross Production Water Use Index (field) (Total) (t/ML)	**1.22**	**0.98**	**1.00**	**0.15**	**0.08**	**0.65**	**1.11**	**3.21**
Total in season effective rain (ML/Ha)	1.83	1.83	1.83	6.34	14.60	8.12	10.15	1.40
Seasonal water usage (Effective Rainfall) (ML/Ha)	3.08	3.23	3.23	6.25	13.89	10.82	12.17	4.37
Gross Production Water Use Index (field) (Effective) (t/ML)	**1.46**	**1.17**	**1.19**	**0.16**	**0.09**	**0.67**	**1.15**	**3.26**

Table: 6: Crop Yield, Irrigation Water Applied and Seasonal Water Usage for three irrigation systems for Australian Cotton – 2010/11.

	Irrigation System	Average	Range	Sample Size
Crop Yield (bales/Ha)	Lateral Move	9.93	5.25 - 14.00	21
	Centre Pivot	9.47	6.87 - 12.00	19
	Drip	11.70	9.12 - 13.48	5
Irrigation Water Applied (ML/Ha)	Lateral Move	2.92	0.50 - 5.17	21
	Centre Pivot	3.08	1.25 - 4.88	19
	Drip	6.32	5.00 - 7.60	5
Seasonal Water Usage (ML/ha)	Lateral Move	7.1	5.40 - 8.00	21
	Centre Pivot	7.18	6.04 - 9.17	19
	Drip	9.23	8.08 - 11.58	5

Table: 7: Summary of Irrigation Benchmarks for the three irrigation systems for Australian Cotton – 2010/11.

	Irrigation System	Average	Range	Sample Size
$IWUI_{field}$ (bales/ML)	Lateral Move	5.09	1.80 - 17.5	21
	Centre Pivot	3.41	2.00 - 5.50	19
	Drip	1.90	1.30 - 2.36	5
$GPWUI_{field,effective}$ (bales/ML)	Lateral Move	1.40	0.70 - 1.90	21
	Centre Pivot	1.33	0.98 - 1.88	19
	Drip	1.28	1.06 - 1.61	5

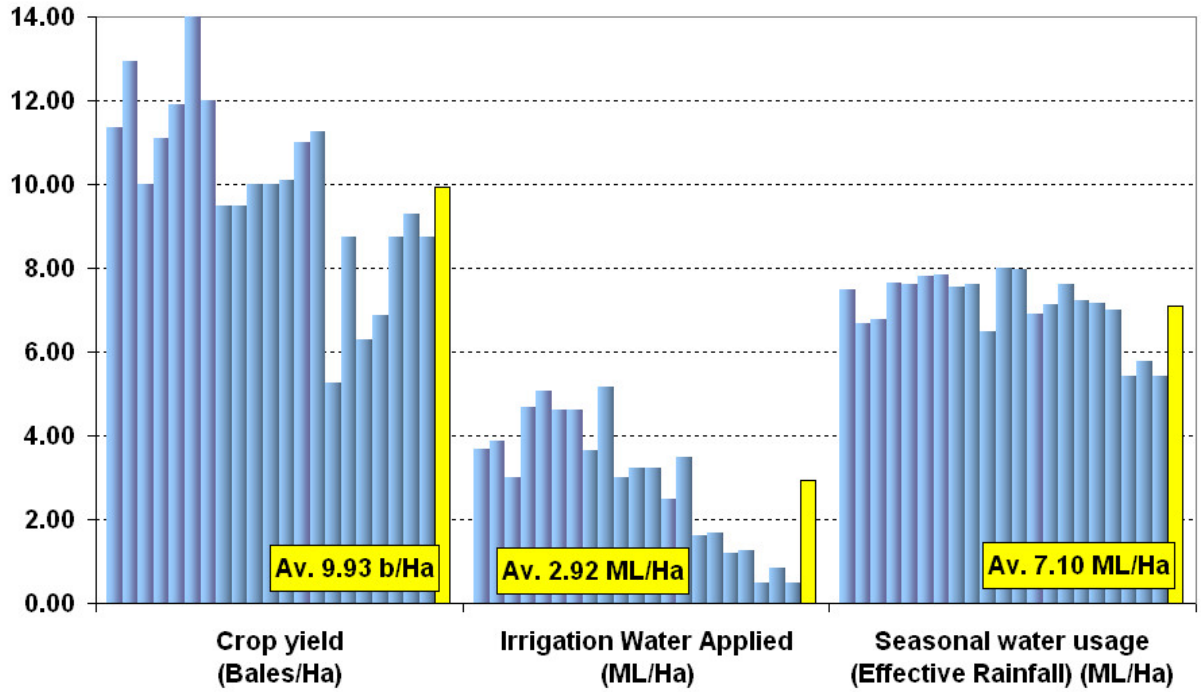


Figure 6a: Variation in Yield, Irrigation Water Applied and Seasonal water usage (effective) for Lateral Move Irrigation Systems– Cotton 2010/11

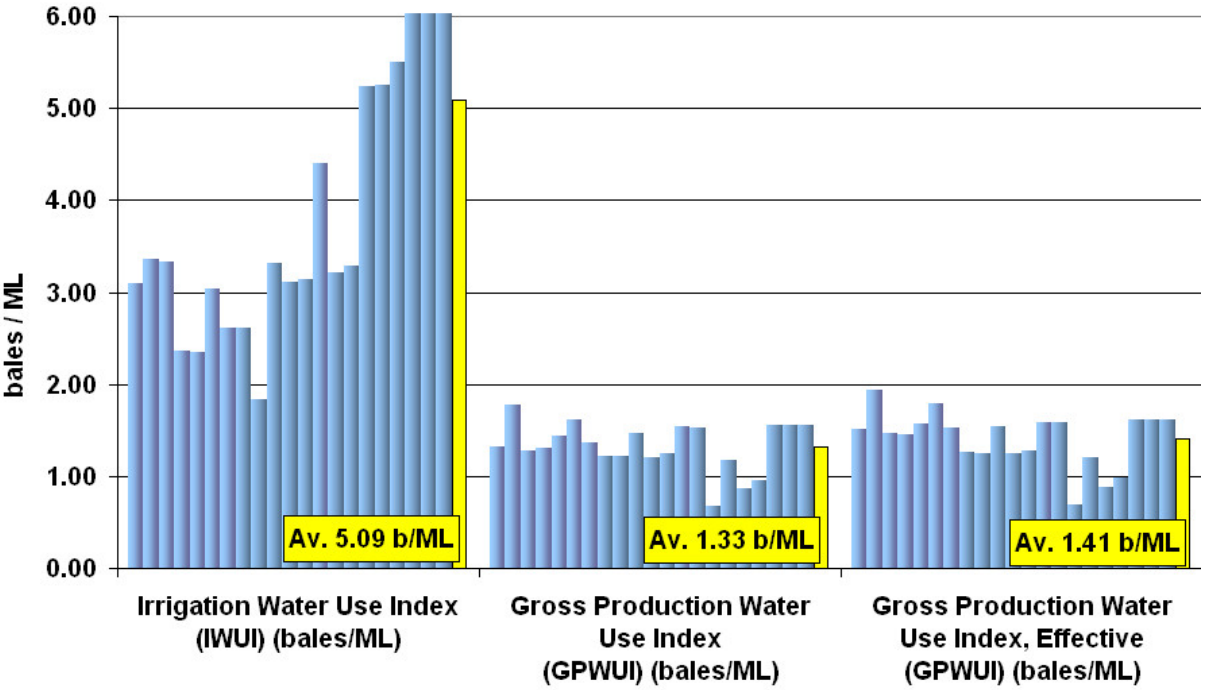


Figure 6b: A Comparison of the Water Use Indices for Lateral Move Systems Irrigation Systems - Cotton 2010/11

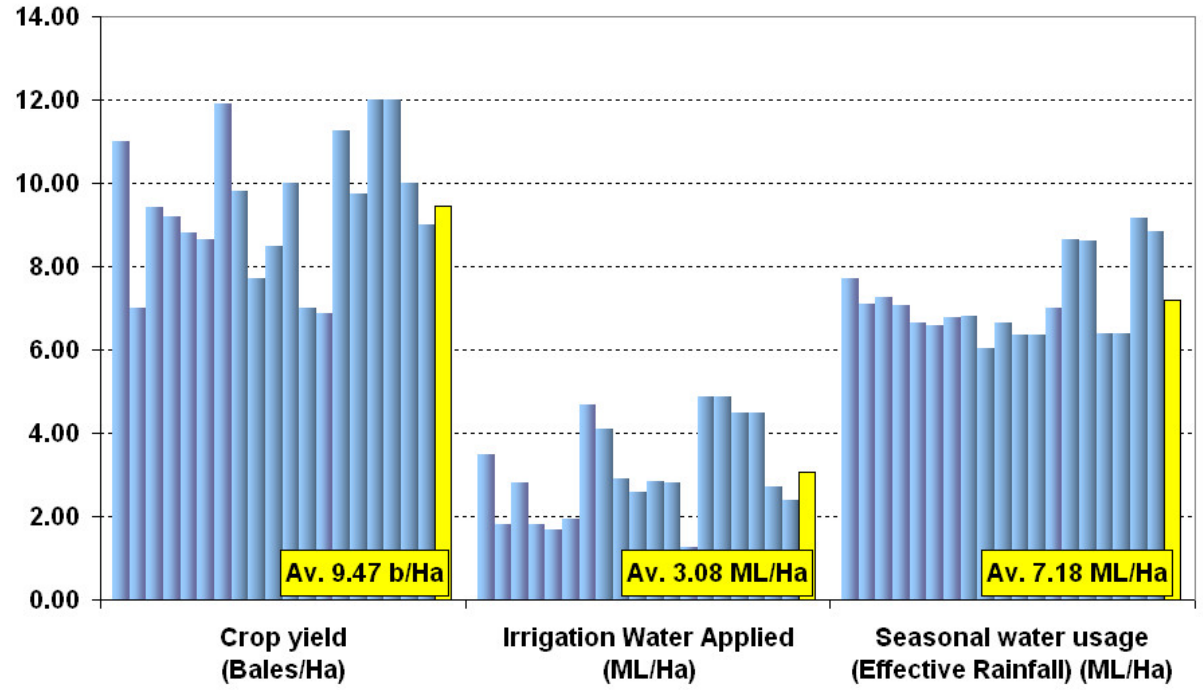


Figure 7a: Variation in Yield, Irrigation Water Applied and Seasonal water usage (effective) for Centre Pivot Irrigation Systems– Cotton 2010/11

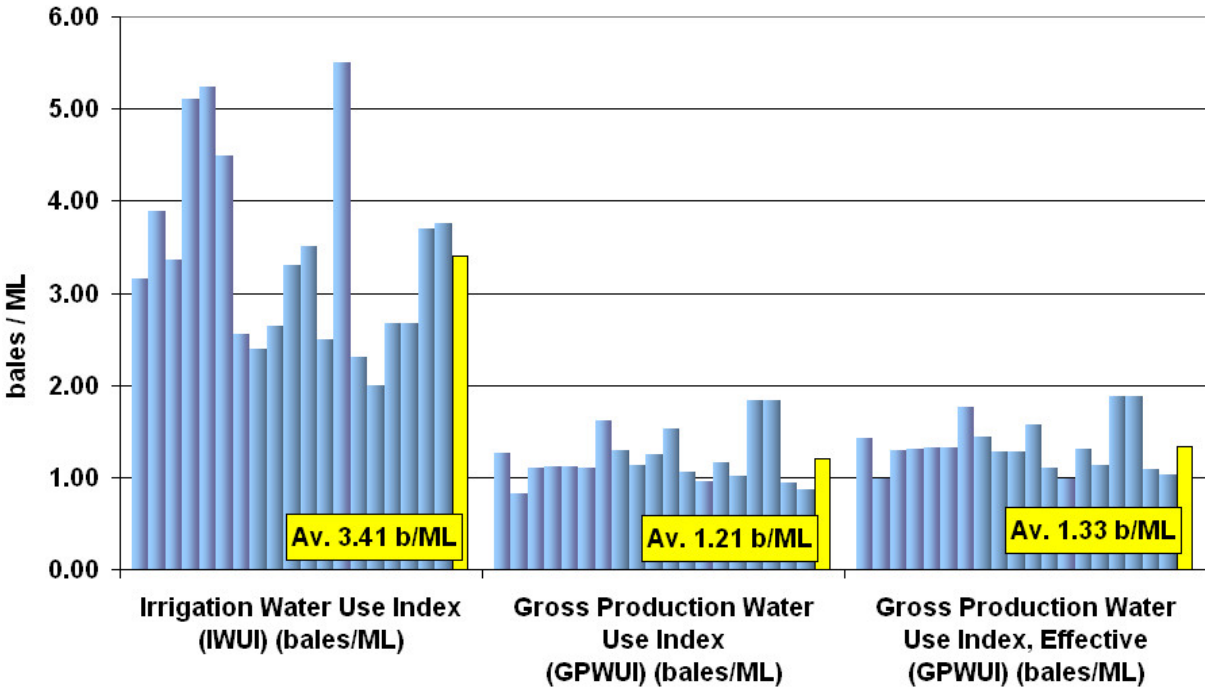


Figure 7b: A Comparison of the Water Use Indices for Centre Pivot Systems Irrigation Systems - Cotton 2010/11

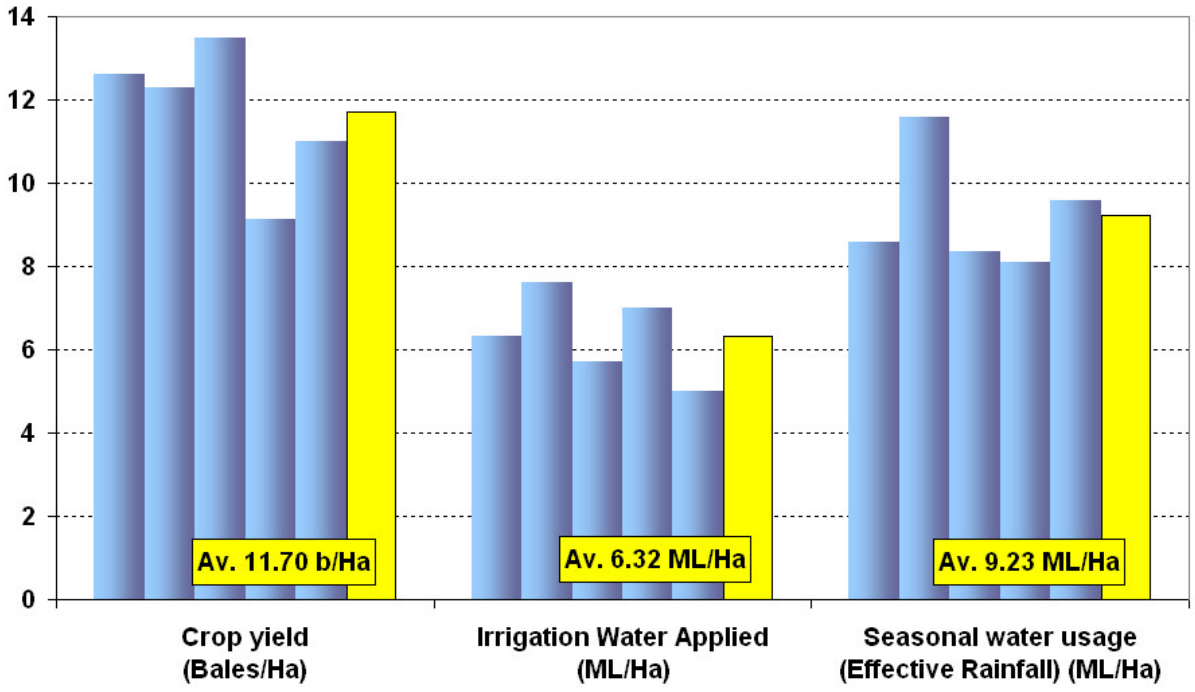


Figure 8a: Variation in Yield, Irrigation Water Applied and Seasonal water usage (effective) for Drip Irrigation Systems– Cotton 2010/11

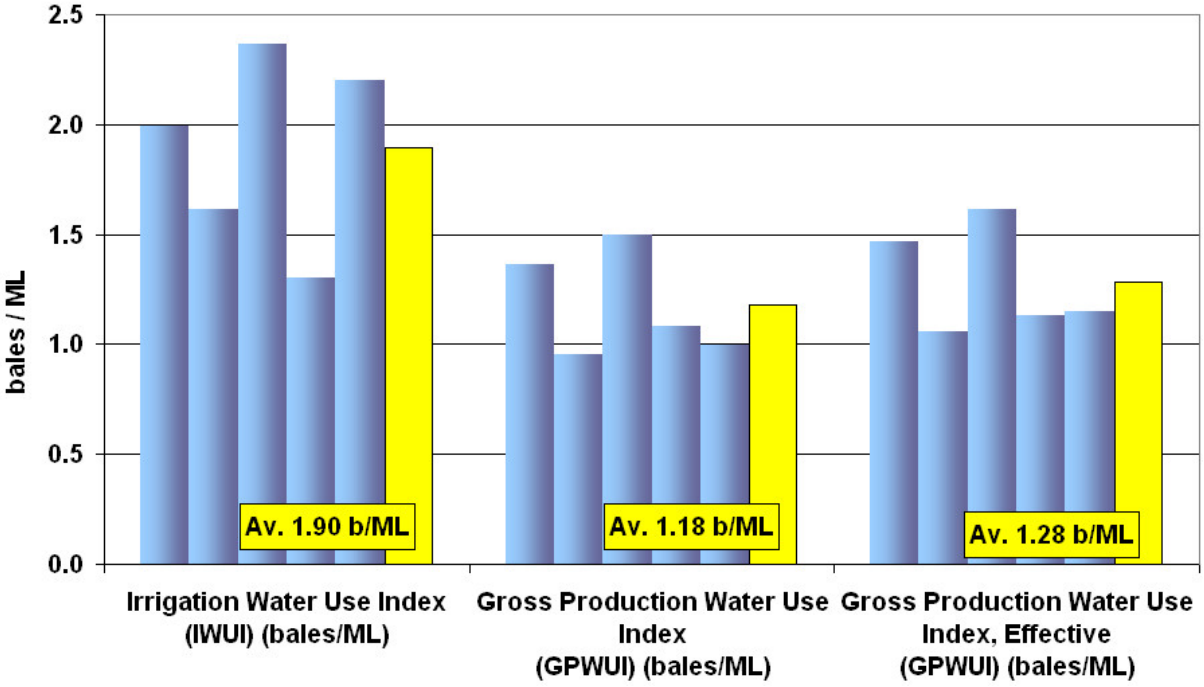


Figure 8b: A Comparison of the Water Use Indices for Drip Irrigation Systems - Cotton 2010/11

Objective 7: Demonstrate IrriSAT SMS in broad acre cotton in Northern NSW.

- *Assist CSIRO researchers to implement IrriSAT SMS for cotton (and/or irrigated grain) in Gwydir Valley.*
- *Engage consultants to trial technology*
- *Farm walk/field day to increase awareness of this technology*

Outputs and Outcomes:

During the 2009/10 irrigation season two Gwydir Consultants (Nick Gillingham and Rob Holmes) were engaged to trial IrriSAT SMS technology in irrigated cotton. The key researchers of this project, John Hornbuckle and Richard Soppe, are based in Griffith, so the support from NSW DPI by local Irrigation Officers was crucial in getting the trial running. This was the first time IrriSAT had been used in broad acre irrigated cotton. Previously it had been used on small acreages in the citrus and horticultural industries in the Murrumbidgee using SMS messaging to deliver irrigation information. The broad acre cotton consultants required a web interface which handled multiple fields and farms. This was a key change to the technology where irrigation information was uploaded and delivered via a web interface.

The trial was expanded during the 2010/11 season. A full report can be found in Appendix 7.

In October 2010, NSW DPI coordinated a series of meetings between CSIRO and local irrigation consultants in the Namoi, Gwydir and Border Rivers regions. The purpose of the meetings was to facilitate collaboration between industry and CSIRO researchers to expand the IrriSAT trial into new regions and include a larger number of consultants.

- 13 consultants (representing 10 consultancy firms) and 3 irrigators from the Namoi, Gwydir and Border Rivers attended these initial meetings.
- 10 consultants signed up to participate in the trial and nominated 305 individual fields/paddocks to be monitored. The total area covered in the Border Rivers and Gwydir valleys for 2010/11 season was approximately 25 000ha. This has provided a considerable range of irrigated cropping practices and climatic ranges to give an excellent test bed for the IrriSAT technology.
- Unfortunately no Namoi consultants signed up for the trial. Record cotton planting that year along with concern for the time the trial may need influenced their decision not to participate. However, all three Namoi consultants have recently confirmed interest to trial the technology during the 2011/12 season if the trial was to continue.
- Collaboration between CSIRO, CSD and GVIA to include an IrriSAT monitoring plot at the Limited Water Trial on 'Red Mill', Moree. The purpose was to allow ground-truthing of the NDVI satellite technology in estimating crop water use against measured soil water use.

2010/11 season was one of Australia's largest cotton production years resulting in an extremely busy season for the participating consultants. Unfortunately the consultants did not continue to update the web interface as often as they had planned, so they did not use the technology continuously over the season. The main reason concerned the large number of fields that the consultants nominated and time required to update the web interface.

The CSIRO researchers visited the consultants again in June 2010 to finalise the input of irrigation data onto the web interface and discuss how IrriSAT can be used and any necessary changes to the technology.

The trial participants raised the concern that the time required by consultants to upload irrigation information was a barrier to the adoption of this technology and, where possible, new ways of automating data input should be investigated.

The CSIRO researchers realise that changes to the interface are required in broad acre cotton production to easily input irrigation data for a large number of fields and farms.

Uses of IrriSAT data identified during the 2010/11 trial include:

1) Determining seasonal and daily crop water use.

2) Looking back retrospectively at irrigation management
Consultant comment: *"It was pretty handy looking back at the data at the end of the season. There was a good correlation between field yields and water use We could look at the data and discuss why this correlation was occurring eg. did the paddock require laser levelling, was it the last block to be irrigated, compaction issues?? It is a good check of what we had hypothesised."*

3) Examine spatial variability across a field or multiple paddocks over a region

4) Ability to differentiate water use with different row configurations.

5) Irrigation Benchmarking
Crop Water Use Index (kg/mm/ha) $$\text{CWUI} = \frac{\text{lint yield (kg/Ha)}}{\text{seasonal Etc (mm)}}$$
Consultant Comment:
"The greatest use I have for using IrriSAT ETc information is for benchmarking my clients' cotton crops. When I'm calculating the crop water use index I need a reliable estimate of ETc. The IrriSAT technology has provided me with this. It's quick and easily obtained for my end of season benchmarks. It reflects the whole paddock, rather than just a single square metre of the paddock. Benchmarking crop water use allows me to look back over the season with my clients and compare crop productivity in terms of water use between fields and farms. We can discuss what might be occurring in field such as compaction, what areas are performing well, etc and try to improve over time."

6) An in-season yield prediction tool

Extension activities conducted to promote IrriSAT:

- 16/12/10 Farm Walk, "Red Mill". NSW DPI provided information on the IrriSAT technology and how the technology was to overlay the limited water and row configuration trial to further ground truth the technology.
- 13-14 January 2011. One-on-one meetings with consultants and CSIRO researchers to provide support for the technology.
- March 2011
    - GVIA Field Day: NSW DPI presented a brief overview of the IrriSAT technology on CSIRO's behalf. 70 irrigators/consultants and agribusiness personnel attended the field day.
    - MacIntyre Field Day: Dr John Hornbuckle from CSIRO gave a presentation on this technology and progress to date in this project. 180 irrigators/consultants and agribusiness personnel attended the MacIntyre field day.
- 03/08/2011 Crop Consultants Australia (CCA) Meeting, Goondiwindi.

- NSW DPI organised for John Hornbuckle, CSIRO Griffith to present information on the IrriSAT technology at the Crop Consultants Australia meeting in Goondiwindi. Approximately 80 consultants attended the meeting and were given information about how the technology works, how it has been developed for irrigated cotton and results of the 2010/11 trial. 14 consultants indicated that they would be interested in trialling the technology next season. They could see the technology had potential, especially for benchmarking crop water use. A number of questions were asked including: 1) impact of cloud cover on satellite imagery and thus Kc. 2) Cost of the technology 3) Inputs required from consultants. Two consultants who trialled IrriSAT in 2010/11 gave an account of their experiences with the technology.

- 23/08/2011 Irrigation Australian Limited (IAL) Conference, Launceston.
  - Janelle Montgomery presented the following paper at the IAL Conference; "Piloting IrriSAT technology in Irrigated Cotton". Questions at end of presentation included 1) What changes were there to the web interface to help input irrigation information? 2) Models are only as good as the weakest link, what do you think the weakest link is? The answer being the quantity of irrigation water applied, so there was then discussion about measurement at the field level. The paper was published in the conference proceedings.

- IrriSAT publications:
  - Montgomery, J. (2010), "SMS Irrigation Water Management Service could be the answer for irrigators", Agriculture Today, May 2010, Industry and Investment NSW.
  - Montgomery J. & Hornbuckle (2010) "Piloting IrriSAT SMS technology in the Gwydir Valley", The Australian Cotton Grower, Volume 31, No. 3, June 2010 – July 2010.
  - Montgomery J. & Hornbuckle J. (2010) "Piloting IrriSAT SMS technology", Cotton Yearbook 2010, The Australian Cotton Grower, Volume 31, No. 5.
  - Montgomery J., Soppe, R., Jackson, R & Hornbuckle J. (2010) "Piloting IrriSAT technology in Irrigated Cotton", Paper presented at the IAL Conference, 22-23 August 2011, Launceston, TAS.

IrriSAT Trial Evaluation

Thank you for your update on the IrriSAT Trial.

From the data that you presented it is clear that the utilising of this technology could open further opportunities to fine tune irrigation scheduling through the extremely accurate whole field measurement of water use.

Auscott Limited currently utilise capacitance probes as a tool to schedule irrigations. Capacitance probes are only accurate if their placement in the field represents the majority of the management unit. I believe frequent IrriSAT images used in combination with accurate weather monitoring devices will provide very accurate information for scheduling. The other clear potential of this technology is utilising the very accurate and reliable E.T. measurements to tell us the actual water use of the plant. Actual plant water use is a figure that in the past has been estimated, now with this information being available on a large scale we can determine which farming systems, agronomic inputs and their timing can provide us with the best water use efficiency.

Auscott wish to continue to support your work in the coming season.

Yours sincerely

Owen Berry
Agronomist - Gwydir Valley
Auscott Limited

IrriSAT Trial Evaluation

I am writing this letter of support for the IrriSAT SMS project because I feel that it will be of value to both me as a consulting agronomist and to cotton farmers in general.

The greatest use I have for the IrriSAT SMS data is the ETc information, I now have a reliable and easily obtained seasonal crop water use for benchmarking my clients cotton crops.

I've never been comfortable with using BOM Silo ETo and my thoughts were confirmed when I compared the Bureau of Meteorology (BOM) ETo with the locally collected ETo data from the IrriSAT weather stations. The difference is around 20 percent. Last season my calculation of crop water use based on BOM ETo were around 8ML/ha, however, using irrisat based water use measurements suggested the crop actually used 11ML/ha during that season. We had some hot windy days where SILO ETo just wasn't representing what was happening in the paddock. The IrriSAT crop water use data followed more closely what the crops where actually using.

I benchmark various crop indices for our clients and water use is one of them. Benchmarking crop water use allows to objectively compare crop productivity in terms of water use between fields, farms and seasons. We can discuss what might be occurring in fields such as compaction and what areas are performing well. With more information about our irrigation performance we can then put plans into practice to improve over time.

Our benchmarking uses the indices and efficiency terms as published in the WATERpak manual (Cotton Research and Development Corporation). Many of the indices require an estimate of crop evapotranspiration (ETc). So when calculating the crop water use index of kg lint/mm/ha, I need a reliable estimate of ETc. The IrriSAT technology has provided me with this. It's quick and easily obtained for my end of season benchmarks. It's simple and reflects the whole paddock, rather than just a single square meter of the paddock.

The web interface needs improvements to handle multiple fields and farms and I have discussed this with CSIRO. There will always be limitation of clouds with satellite images, but there are limitations with most technologies. My feedback has been valuable in improving the interface to make it more suitable for cotton consultants and growers. Continuing the trial would give me the opportunity to use the new interface which could lead to even more improvements down the track.
Please keep up the good work with the IrriSAT project.
Sincerely,
Rob Holmes
HMAG, Moree

IrriSAT Trial Evaluation

I have been working with John Hornbuckle and Richard Soppe, CSIRO trialling the IrriSAT Technology for the last two cotton seasons. The ability to measure crop water-use accurately has been limited as a representative ETo measurement and site specific crop coefficient (Kc) have not been available. The IrriSAT technology includes weather stations

equipped to measure local ETo and when combined with localised, site specific Kc, a more accurate measure of crop water use (ETc) can be obtained. I have been using soil moisture measurements to help make scheduling decisions. The ability to measure daily crop water-use using the IrriSAT technology, which provides information on a large spatial scale, will help guide our decisions. IrriSAT also includes a 7 day forecast which is useful in forward planning.

A seasonal crop water-use figure can be used to benchmark the crop water-use index (kg lint/mm/ha), to compare water-use between different fields. We need to have confidence in the CWU figure, and the IrriSAT technology is providing us with this confidence.

It is early days, but the technology can possibly help us with yield forecasting. Further work is required by the researchers, but it may be possible to predict yield from Kc maps produced in late January.

The IrriSAT Program requires further refinement to handle large number of fields and farms. I believe the CSIRO researchers have a better understanding of our needs and how they can be incorporated into the program. Time is limited and there are dozens of tools out there, so ultimately I would like to see crop water-use and soil moisture data presented in one program. As such, I fully endorse a continuation of the IrriSAT trial in the cotton industry.
Yours Sincerely,
Nick Gillingham
General Manager – Keytah
Sundown Pastoral Company

Objective 8: Liaise with extension, industry and regional networks to update project progress, ensure non-duplication of effort and a coordinated approach to dissemination of outcomes

There has been significant collaboration between Water Smart Cotton and Grains and industry organisations including:

- ***Gwydir Valley Irrigators Association (GVIA)***
    - NSW DPI have provided technical advice and conducted field work associated with the "Red Mill" Limited Water Trial & Keytah Irrigation Systems Trial.
    - In partnership with the GVIA & CSD's James Quinn, NSW DPI conducted an Irrigation Efficiency Field Day at "Red Mill" Moree on the 21st March 2011. New approaches to increasing WUE were conveyed to 45 local irrigators and 25 members of the National Irrigators Council by the presentation of preliminary results from the cotton planting configuration and watering regime trial.
    - "Red Mill" Limited Water & Row Configuration Trial results were published in the Australian Cotton Grower:

  Broderick, R., Quinn, J., Farrell, Z., Jackson, R., Montgomery, J., Stone, M., Young, A., Fox, R. & Robinson, J. (2011). "Less crop but more drops" Australian Cotton Grower, Vol. 32, No. 4, Aug-Sept 2011.

- ***Cotton Catchment Communities CRC***
    - In November 2010, feedback and general recommendations were provided on the content of the report by Powell, J. and Scott, F. (2010) *Irrigated Farming*

Systems in the Northern Cropping Region of NSW – Lower Namoi Valley. Economic Research Report No.46

- Namoi Ground Water Forum, Tamworth December 3 2010 – NSW DPI Project staff interacted with leading ground water researchers and industry personnel, many having been funded by the Cotton Catchment Communities CRC
- High yielding irrigated grains in cotton farming systems GRDC project CCC00004. Collaboration with this project continued with input from project staff for irrigation timing and volume, installation of soil moisture monitoring equipment and benchmarking of irrigation performance for the deficit trials conducted at 'Auscott' Narrabri for 2009, 2010 & 2011 winter cropping seasons.
    - 21/06/2011 Irrigated wheat seminars - A breakfast and afternoon meeting were held at Wee Waa and Moree respectively to extend preliminary results from the High Yielding Irrigated Grains project. Specific topics included; plant establishment, crop nutrition, disease management, and irrigation scheduling. Rod Jackson prepared information on irrigation scheduling and presented at these meetings. A total of 15 irrigators attended the meetings.
- Collaboration with the CCC CRC Storages Project to engage the consultants in the Watertrack Rapid^{TM} Survey. Irrigators who have had their water use efficiency benchmarked as part of the Water Smart Cotton and Grains project were cross referenced with irrigators participating in the storages project. These irrigators can partition their water losses into a storages component and a distribution & field component. Technical advice and local input was also given to Project Officers who developed case studies for this project.
- Speaker at the CCC CRC's Australian Cotton Water Story. Provided an update on research and extension in this area since 2005 and future directions to guide future cotton water research. The following paper went into their proceedings:
    - Montgomery, J (2011) 'Water Use Efficiency Benchmarking and Optimising Furrow Irrigation', Australian Cotton Water Story, A research Review. 10-11 August 2011, Narrabri.

- ***Cotton Industry Development and Delivery Team***
    - Participate in the cotton industry Development and Delivery Team teleconferences.

- ***Catchment Management Authorities***
    - Groundwater Monitoring and Management Workshops March 2010 - In partnership with the Namoi CMA and Cotton Catchment Communities CRC, NSW DPI presented management strategies for irrigators using poor quality groundwater. 20 irrigators and industry personnel attended the workshops in Gunnedah and Wee Waa.

- ***National Centre for Engineering in Agriculture***
    - Evaporation mitigation and furrow automation technology demonstration.
    - Collaboration on extension articles.

- ***Irrigation Australia Limited (IAL)***
  - NSW DPI project staff are active members of the North West NSW Regional Committee. NSW DPI attend monthly meetings and help organise or contribute to IAL annual field days:
    - 27/08/08 Energy in Irrigation, Goondiwindi
    - 26/11/09 Metering – Policy and Standards & Inspection of Irrigation System Trial, Moree
    - 4/08/11 Reducing pumping costs and energy efficiency, Narrabri
  - 14-15 September 2011, Helped facilitate the locally delivered IAL Metering Course in Moree.

Dear Janelle, Just a short note to thank you very much for your professional organisation of the Metering Course.....From Mike Rankin, Managing Director Water Training Australia.

  - NSW DPI Irrigation Officer Peter Smith is actively involved in the CPLM Special Interest Group which has been made aware of WSC&G CPLM work

Evaluation of NW IAL Reducing pumping costs and energy efficiency seminar, Narrabri

In collaboration with IAL NSW DPI coordinated an irrigation pumping and energy efficiency seminar giving irrigators, consultants and retailers the opportunity to hear from a wide range of speakers on ways to reduce pumping costs and optimise energy efficiency.

A successful day with good discussion and questions from the 45 participants after most speakers.

Key topics included: diesel gas pump conversions, variable speed electric drives, whole farm energy efficiency auditing, pump station upgrades and pump selection, bore maintenance, and energy consumption comparisons between CPLM and surface irrigation systems.

Hi Janelle,
Firstly thank you and your team for a great and interesting day out on Thursday. I really enjoyed all the presentations and thought it was a fantastic morning. I would really appreciate it if I could get a video or transcript copy of Jim's presentation.
Kind Regards
Mary Philp
Economist , Qld DEEDI

NSW DPI also engaged David Larsen (Technology Resource Centre Coordinator, Cotton Catchment Communities CRC) to video the presentations. These have been posted on the Cotton CRC website
http://www.cottoncrc.org.au/industry/Publications/Water/Irrigation_Systems/Pump_Efficiency

The link was emailed to all people that attended the seminar, along with industry networks. Figure 6 shows the number of page hits for each of the presentations. There have been over 100 hits on the main web page and interestingly the most popular presentation in terms of hits has been pump fundamentals.

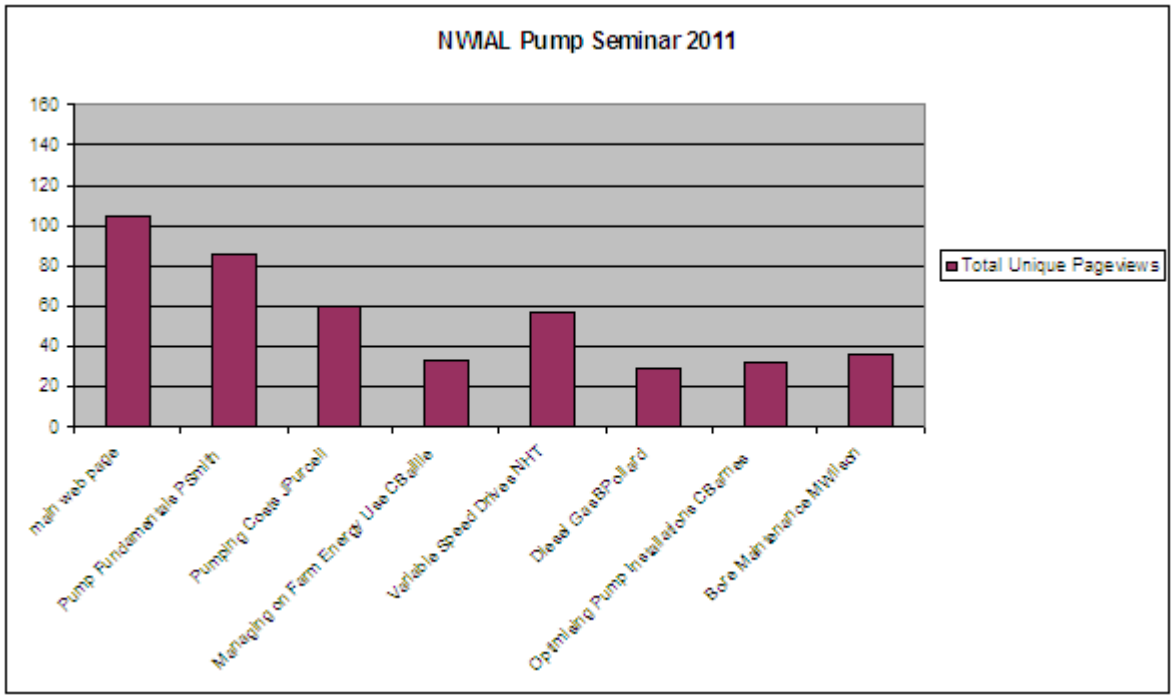


Figure 6: Number of unique page views for pump and energy efficiency presentations (25/10/11)

- ***Lower Namoi Cotton Grower Association***
  - Rod Jackson NSW DPI has been working closely with this grower organisation in the delivery of irrigation training eg. the groundwater management and monitoring workshops in March 2011.
  - There was strong interest in on-farm energy use and costs, particularly pumping costs. As a result Rod Jackson organised for the North West IAL branch to hold its annual field day in Narrabri with the topic Reducing pumping costs and energy efficiency.

- ***Commercial irrigation***
  - There has been a resurgence of interest in drip system in larger scale cropping enterprises, so project staff have been collaborating with Netafim and Tandou Ltd to produce a video on management techniques for these systems. This was to take place in January, but has been postponed until a more suitable time. It is envisaged that irrigators and consultants from the Border Rivers and Gwydir Valleys will attend a field day where filming will take place.
  - NSW DPI collaborated with Netafim to develop an Introduction to Drip Workshop and Netafim assisted in the delivery of the pilot workshop in Moree, 18/08/2010.

- ***High-yielding winter cereal genotypes for irrigation for south-eastern Australia GRDC project***
  - In the Murrumbidgee valley, NSW DPI staff provided technical advice and support to the GRDC 'High yielding winter cereal genotypes for irrigation for south eastern Australia' project ICF00007, particularly for irrigation scheduling and capacitance probe installation and maintenance.

- Specialist technical advice has also been provided to GRDC funded researchers on the planning and design of a managed environmental facility at Yanco research station, NSW. This facility will have a rainout shelter and a high precision irrigation system.

- ***NSW Sustaining the Basin: Border River-Gwydir (STBBRG)***
  - This pilot project is a Federal Government irrigation infrastructure modernisation program which ran in the Gwydir Valley from Oct 2009 – April 2011. Irrigation training was aligned to specific technologies and on-farm works that irrigators may be considering with incentive funds. The training and extension opportunities associated with STBBRG have contributed towards the overall aim of the WSCG project "To improve knowledge transfer and to build capacity with NSW Cotton and Grains industries to adopt best irrigation practice".

- ***CSIRO, IrriSAT technology trialled in irrigated cotton.***
  - NSW DPI provided local support to the IrrisSAT trial, by engaging irrigators and consultants and producing extension material. Magazine articles and conference papers were written in collaboration with CSIRO. Janelle Montgomery presented a summary of the trial at the 2011 IAL Conference.

- ***UNE Cotton Course***
  - Rod Jackson, Irrigation Officer, Narrabri, delivered the parts of the Irrigation and Farm Design module of the Cotton Production Course to students at ACRI.

- ***QLD DEEDI & DERM.***
  - Irrigation Officers based in NSW & Qld keep contact through email, phone calls and industry meetings. The following collaboration has occurred:
    - Irrigation articles for the Australian Cotton Grower
    - Collection of irrigation benchmarks for the cotton and wheat irrigators.
    - Data sharing – As part of the Healthy Headwaters Irrigation Infrastructure Project, irrigation benchmarks were collected from 31 irrigators who had centre pivot and lateral move irrigation systems. These data were added to the NSW DPI overhead irrigation benchmarks to provide a larger sample size and whole of industry results.

- ***High Security Irrigators–Murrumbidgee.*** NSW DPI delivered eight Farm Efficiency Workshops to irrigators in various locations in the Murrumbidgee and Lachlan valleys as part of an Adapting to Climate Change project.

- ***NVT (National Variety Trials***) Iva Quarisa, Irrigation Officer, is responsible for installing soil moisture monitoring equipment, monitoring soil moisture and scheduling irrigations for the irrigated winter grain trial plots. Information about crop water use & irrigation scheduling is provided to the farmer and at the NVT field days.

7.0 Conclusion

The Water Smart Cotton and Grains project has made a significant contribution towards the cotton and grains industries adoption of irrigation best management practice. Evidence in this report documents an improved knowledge of irrigation best practice as well as adoption of new technology and practice change.

Thirty irrigation and crop consultants worked with NSW DPI and improved their skill and understanding of a range of irrigation services such as soil moisture monitoring, measuring crop water use, irrigation benchmarking, flow metering and evaluating pump performance.

Irrigation training was a major output of this project with 253 cotton and grains irrigators, 125 consultants, 18 irrigation retailers and 40 industry personnel (agribusiness, extension officers) attended 35 irrigation workshops. Evaluation from these workshops show irrigators have a better understanding of irrigation best practice and indicated that they had learnt skills that they would take away and apply at home including adoption of irrigation benchmarking techniques, improved management of on-farm irrigation storages (such as surveys to obtain an accurate depth – surface area – capacity relationship and evaluation of seepage and evaporation), improved understanding of irrigation performance evaluation and methods used for assessment, along with greater management skill in operating and maintaining centre pivot, lateral move and drip irrigation systems.

In this project, formal training workshops have played an important part in achieving better understanding of irrigation best practice, and participatory learning through on-farm trials and technology demonstrations multiplied this and effectively improved adoption of best practice.

An important outcome of this project has been the establishment of irrigation benchmarks for the cotton and grains industries. The average $GPWUI_{farm}$ for the cotton industry for the 2008/09 season was 1.14 bales per megalitre. It confirmed the previously revealed 40 per cent improvement by NSW DPI, since the last industry estimate 10 years ago. For irrigated wheat, this is the first industry wide data collected. The average $GPWUI_{farm}$ for irrigated wheat for the 2008 season was 0.85 tonnes per ML.

The collection of high quality cotton water use efficiency data will enable industry representatives (e.g. Cotton Australia) and government policy makers to make sound policy decisions based on facts and not estimates. Establishing water use efficiency benchmarks will enable the irrigated cotton and grains industry to monitor and determine the magnitude of industry water use efficiency gains in coming years.

Ideally the collection of irrigation benchmarks would involve industry consultants. This project put significant effort and resources into engaging consultants, providing them with the necessary skills for irrigation benchmarking. Unfortunately the uptake of Watertrack Rapid^{TM} by consultants to benchmark their clients did not occur. Time and dollars were the main limitations to adoption of this benchmarking tool. Although water is important to the production system, adoption of new water technologies from consultants can be inhibited by the higher priority of daily tasks that require timely management eg pest, weeds, disease and

nutrition. There are obvious differences between agronomic and irrigation consultants in their interest and adoption of water technologies.

Irrigation benchmarks were also collected for lateral move, centre pivot and drip irrigation systems. There was a wide variation in irrigation water applied, seasonal water use and the water use indices. At this field level, management has a significant influence on the performance of these systems in terms of bales or tonnes per ML produced.

The project included significant collaboration with irrigation industries, research organisation and other extension services which improved the capacity building opportunities available to irrigators and consultants. NSW DPI Irrigation Officers have built a wide network including key irrigation organisations and personnel with which we have a strong rapport.

8.0 Recommendations:

8.1. Collection of industry irrigation benchmarks: The importance of these data for industry is well documented within this report. The two surveys completed by NSW DPI for the Australian Cotton Industry took place in 2006/07 and 2008/09. These two seasons had relatively low plantings with 35,000 Ha in 2006/07 and 18,000 Ha in 2008/09 due to reduced water availability as a result of drought and low cotton price. More recently cotton area has significantly increased with 378,180 Ha irrigated cotton grown in 2010/11 and the irrigated cotton area is expected to be as high as 463,180 Ha in 2011/12. Obviously it is important to continue to benchmark irrigation water use efficiency over time as conditions change from season to season. A comparison of the low water, low acreage years of 06/07 and 08/09 with high water and acreage years would provide some interesting information for industry. Are the irrigation benchmarks achieved when water is short and management more intense due to smaller cotton plantings also achieved in a year when a farm is in full production?

8.2. On-farm energy use efficiency. A topic that has emerged over the duration of the Water Smart Cotton and Grains Project is on-farm energy use efficiency. Irrigators often question the energy use when comparing different irrigation systems. Work by NCEA show how cotton farms are highly mechanised with irrigation accounting for between 40 and 60 percent of on-farm energy costs. They have found energy use on-farm to vary quite significantly between farms. There is opportunity for irrigators to start benchmarking on-farm energy use, along with their water use efficiency.

8.3. Consultant support program: While consultants continue to play an integral part in Australian crop production, they remain an essential link to engage irrigators and achieve adoption of irrigation best management practice. Consultants should continue to be engaged to participate in industry trials, field days and irrigation training. Industry needs to be able to support, as well as draw knowledge from the experienced consultants and provide support to new graduates or consultants new to the cotton or grains industries.

8.4 Training: Irrigation training should continue to be available for irrigators. It plays an important role in improving irrigators knowledge and awareness of irrigation practices resulting in practice change. Workshops need to be continually updated and reviewed to ensure content remains relevant. Participatory learning provides hands-on experience and should be encouraged within irrigation extension to improve adoption of best management practice and new irrigation technologies.

8.5. Cotton and Grains WATERpak upgrade: To ensure the completion of an updated WATERpak manual, industry should develop a dedicated project. Although the updates and reviews may include industry researchers and extension officers, the project requires a single driver to make it happen. A steering committee that includes representatives from both the cotton and grains industry is essential to not only vet content, but to also ensure industry participation for information gathering, writing and reviewing.

8.6. Water extension in the cotton industry: Folding of the Cotton Community Catchments National Water Team has impacted on water extension to some degree. The Water Team provided a National body which was not divided by State boundaries. The Qld and NSW based projects did have similar objectives at the time which increased the collaboration between agencies. However, the Water Team made collaboration more accessible with monthly teleconferences and uninhibited sharing of knowledge and resources. It was an important network, whose legacy remains. Although collaboration still takes place in a variety of forms between different organisations, some formalisation would ensure more regular contact of industry water extension officers and researchers, non-duplication and more frequent and un-inhibited sharing of knowledge and resources.

8.7. Extension for improved infrastructure investment. During the Water Smart Cotton and Grains project, significant water reforms have been occurring. Water Sharing Plans have been implemented and more recently the Murray Darling Basin Authority is developing the Basin Plan. As a result of these reforms the availability of irrigation water has already been reduced, and it is likely to be further impacted with a reduction in irrigator entitlements. Irrigators will be looking carefully at their current infrastructure and making changes that result in water savings in order to adapt to reduced allocations. Infrastructure changes have already taken place, and accelerated in some instances, with the availability of funding through CMA's or the Australian Government's 'Water for the Future' initiatives. Support needs to continue to be available to irrigators that are making infrastructure investment decisions. Irrigators need to be equipped with the knowledge and management skills to ensure new infrastructure is providing the water savings envisaged.

9. A. List the publications arising from the research project and/or a publication plan.
A list of publications is provided in Appendix 5.

(NB: Where possible, please provide a copy of any publication/s)

Have you developed any online resources and what is the website address?

A list of on-line resources is provided in Appendix 5.

Part 4 – Final Report Executive Summary

Provide a one page Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web. Explain the main outcomes of the research and provide contact details for more information. It is important that the Executive Summary highlights concisely the key outputs from the project and, when they are adopted, what this will mean to the cotton industry.

Water Smart Cotton and Grains is a water use efficiency project that improved knowledge transfer and built capacity within these industries to adopt best irrigation practice. It followed on from the achievements of the 'Knowledge Management in Irrigated Cotton and Grains' and 'Advancing Water Management in NSW' projects to further improve water use efficiency within the cotton and grains industries.

Water Smart Cotton and Grains incorporated a comprehensive capacity building program including training workshops, technology demonstrations, consultant mentoring and dissemination of irrigation information, to increase the knowledge and awareness of irrigation best practice and of new irrigation technologies and to improve on-farm water management and irrigation efficiency within the Australian irrigated cotton and grains industries.

In order to know what change in water use efficiency is occurring, industry needs to know how it is currently performing. An important outcome of this project has been the establishment of irrigation benchmarks for the cotton and grains industries. The average $GPWUI_{farm}$ for the cotton industry for the 2008/09 season was 1.14 bales per megalitre. It confirmed the 40 per cent improvement that was previously revealed by NSW DPI, since the last industry estimate 10 years ago. For irrigated wheat, this is the first industry wide data collected. The average $GPWUI_{farm}$ for irrigated wheat for the 2008 season was 0.85 tonnes per ML.

The collection of high quality water use efficiency data will enable industry representatives (e.g. Cotton Australia) and government policy makers to make sound policy decisions based on facts and not estimates. Establishing water use efficiency benchmarks will enable the irrigated cotton and grains industries to monitor and determine the magnitude of industry water use efficiency gains in coming years.

Thirty irrigation and crop consultants worked with NSW DPI and improved their skill and understanding of a range of irrigation services such as soil moisture monitoring, measuring crop water use, irrigation benchmarking, flow metering and evaluating pump performance.

Irrigation training was a major output of this project with a total of 35 training events delivered to 436 cotton and grains irrigators, consultants, retailers and industry personnel. Evaluation from these workshops shows participants have a better understanding of irrigation best practice and learnt skills that they could apply at home including adoption of irrigation benchmarking techniques, improved management of on-farm irrigation storages and increased understanding of irrigation performance evaluation and methods used for assessment, along with greater management skill in operating and maintaining centre pivot, lateral move and drip irrigation systems.

The project included significant collaboration with irrigation industries, research organisations and other extension services, which improved the capacity building opportunities available to irrigators and consultants. NSW DPI Irrigation Officers have built a wide network including key irrigation organisations and personnel with which they have a strong rapport.

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