C° On-farm irrigation optimisation trials in 2005/06

Dirk Richards[a] and Andrew Murray[b]
[a] CSIRO Plant Industry, Narrabri, NSW
[b] Aquatech Consulting Pty Ltd
Cotton Catchment Communities Cooperative Research Centre

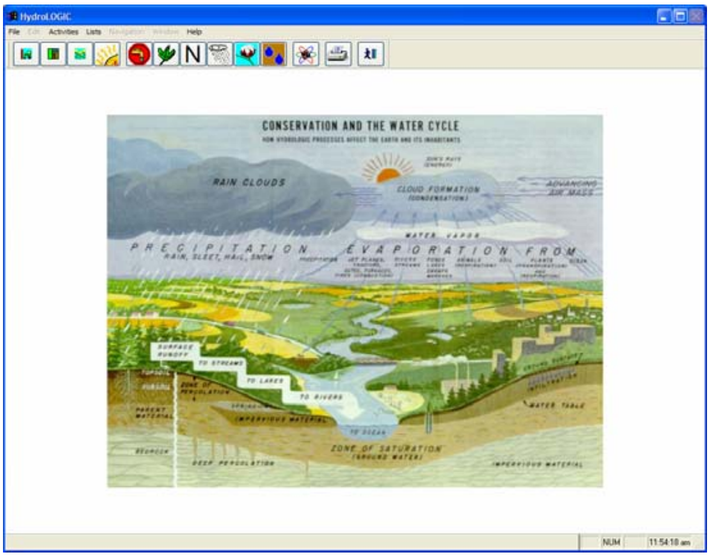
An increasing focus on water for irrigation within Australian agriculture and the cotton industry has encouraged several new services and tools to be developed. Tools such as the HydroLOGIC irrigation management software have been produced to help irrigators determine when the best time to irrigate is and whether there are potential consequences of scheduling decisions on crop growth and yield. The Irrimate™ Surface Irrigation Evaluation Service consisting of a range of tools and software has been developed to measure how much water is being applied and how irrigation events can be optimised. To monitor and manage water over the whole farm, the WaterTrack™ software has been developed, allowing daily farm water balances to be calculated under present and future water availability scenarios. It is important to consider that each of these tools generates focussed information to assist in decision making on different questions.

Two experiments have been established in the Namoi Valley during 2005-06 to showcase these irrigation tools and to explore means of integrating these technologies. These research sites are located on farms at Burren Junction and Boggabri, and involve storage surveys, the installation of sensors for continuous volume information, and in-field application monitoring equipment. Plant growth and water use is being monitored by fruit count, leaf area estimation, and using capacitance and neutron probes. On these farms, a single field was selected and split into standard and optimised irrigation treatments. Scheduling and application on the optimised treatment is determined through HydroLOGIC and Irrimate™ evaluations, with final yields and water use indices in the optimised treatment to be compared with the remainder of the field and the whole farm average. The WaterTrack™ software is being run for the whole farm which includes the field being monitored. At the end of the season, WaterTrack™ will be used to predict the optimum planting arrangement based on future water availability. When required, the growers have changed their irrigation schedule and water application technique.

What are the tools?

HydroLOGIC

The HydroLOGIC irrigation software has been developed to assist in the effective and timely application of irrigations for furrow irrigated cotton crops. The engine behind HydroLOGIC is the OZCOT cotton model, which has been developed over many seasons in Australian cotton crops. Soil moisture balance, crop growth and evapotranspiration are calculated daily, which means the implications of changes in irrigation management are predicted daily. The software has the ability to evaluate the yield consequences of different irrigation strategies using a range of simple plant and soil moisture measurements. While growers may have the approximate timing of their irrigations correct, HydroLOGIC has the potential to finetune field management and possibly highlight opportunities to save water, in particular when situations change (eg with reductions in water allocation). The fundamental benefit of the crop model approach is the ability to predict daily and react dynamically to leaf area growth, the soil moisture balance and rooting depth which can change in response to climate and crop management.



Irrimate™

The Irrimate™ In-Field Evaluation Service includes measuring equipment and computer modelling software. It allows accurate measurement of irrigation efficiency and infiltration at any point down the field. An irrigation may then be optimized by modelling different irrigation practices such as changes in siphon flow rates, irrigation shift times, field length, and field slope. This allows the most efficient irrigation application strategy to be established for each field and soil type to meet the target deficit or desired application amount.

In addition, Irrimate™ has developed a Seepage & Evaporation meter and a Storage Meter. The Seepage & Evaporation Meter accurately measures seepage and evaporation losses from storages, channels and drains, while the Storage Meter continually measures and records storage volume, water surface area, and storage depth (Figure 1).

Figure 1. Storage meter (left) and calibration meter (right)

WaterTrack™

Using WaterTrack™ an irrigator can determine where the farm water is going and how much is available for use at any point in time, now or in the future. WaterTrack™ records water transfer through every structure and operation on an irrigated farm including supply channels, storages, head ditches, taildrains, fields, and tail water return. The wetting up of soil (in channels, storages, fields and drains), seepage, and deep drainage are calculated to provide a daily soil water balance. All normal activities relating to irrigation are entered into the program. Daily weather data containing rainfall and evapotranspiration (Et_0) is used to calculate daily evaporation losses from soil and water surfaces in storages, channels and drains, and to estimate crop water use. Water brought onto the farm is measured using existing pump meters, and in this project changes in storage volume from harvested on-farm are being measured using the continuous records of storage volumes from the Irrimate™ storage meter. This information is then used by WaterTrack™ to calculate a daily water balance over the whole farm. Future water use can then be predicted for any year, allocation, or change in farm management or design.

Integration of tools

One of the main aims of this research effort is to investigate the potential for integration of HydroLOGIC, Irrimate™ and WaterTrack™. These tools target different on-farm water issues and the information generated within each tool can contribute to the value of the others as a whole. For example, Figure 2 illustrates one way the three tools may be linked to generate information for in-season irrigation decisions, with the ultimate aim to optimise whole farm water use.

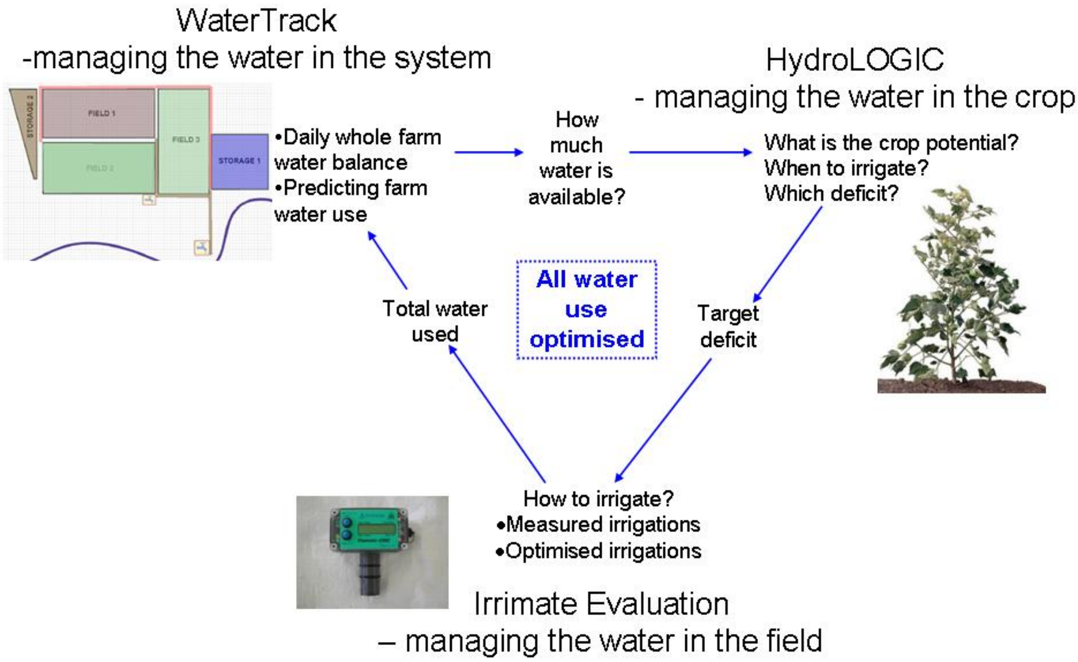


Figure 2. Conceptual integration of water management tools

Results to date

Crop observations

The standard and optimised treatments in the experiments have grown slightly differently in spite of identical crop agronomy and irrigations being relatively close together. Visual differences were seen in leaf area, plant size, and row closure during December and January. Differences in the rooting depth were apparent in mid November at (40cm depth) and leading up to first irrigation (60cm depth), which was confirmed using capacitance and neutron probes. Fruit numbers have not differed greatly between the treatments at either site and plant mapping will be done in both treatments to confirm differences in fruit retention and crop development.

Standard treatment, Burren Junction (Jan)

Optimised treatment, Burren Junction (Jan)

Irrigations to date

Rainfall during early crop growth has made a considerable impact on the scheduling and timing of in-crop irrigations. Rain totals to March were 231mm at Burren Junction and 477mm at Boggabri, which has reduced irrigation frequency. At Burren Junction, HydroLOGIC has predicted irrigations very close to the standard practice confirming the current scheduling is close to optimum. At Boggabri there has been 3 to 7 day differences in irrigation date, showing potential for change if bore supply and field rotation allow.

Burren Junction site irrigations

Standard	Deficit	Optimised	Deficit
9-Dec	77mm	10-Dec	78mm
26-Dec	68mm	27-Dec	90mm
4-Jan	81mm	5-Jan	101mm
13-Jan	92mm	14-Jan	109mm
24-Jan	89mm	25-Jan	99mm
2-Feb	95mm*	3-Feb	89mm*
13-Feb	135mm	14-Feb	128mm

* calculated using HydroLOGIC

Boggabri site irrigations

Standard	Deficit	Optimised	Deficit
30-Dec	103mm *	27-Dec	83mm
18-Jan	81mm *	11-Jan	92mm
29-Jan	95mm	28-Jan	91mm
7-Feb	81mm	8-Feb	75mm
24-Feb	83mm	27-Feb	87mm
11-Mar	98mm		

* Estimated from neutron probe and calculated evapotranspiration (FAO56)


Standard treatment, Boggabri (Jan)   Optimised treatment, Boggabri (Jan)

Irrigation application

Water application and amount of infiltration has been measured at each irrigation using the Irrimate siphon meters, advance sensors, and tailwater flume flow meters (Figure 3). The information collected indicates that soil type and soil management have a considerable impact on the optimum irrigation practice.


Figure 3. Irrimate siphon meter (left) and flume meter (right)

On the heavy grey vertosols of Burren Junction, the early irrigations took the initial 30 - 40 mm of infiltration quickly (within 20 to 30 minutes), with the remaining irrigation having a low infiltration rate of around 2mm/hour and therefore taking a long time to infiltrate a small amount of water (Figure 4a). Irrimate evaluations through the season showed that the soils ability to absorb water decreased as the season progressed. On this farm the soil settles through the season and its infiltration characteristics change. Irrimate has shown that the existing irrigation practices are extremely efficient. This supported the farmers experience on this farm, in that by having a large capacity to circulate water they can meet the crops demand quickly, despite the reduced infiltration, thus limiting potential waterlogging of the crop.

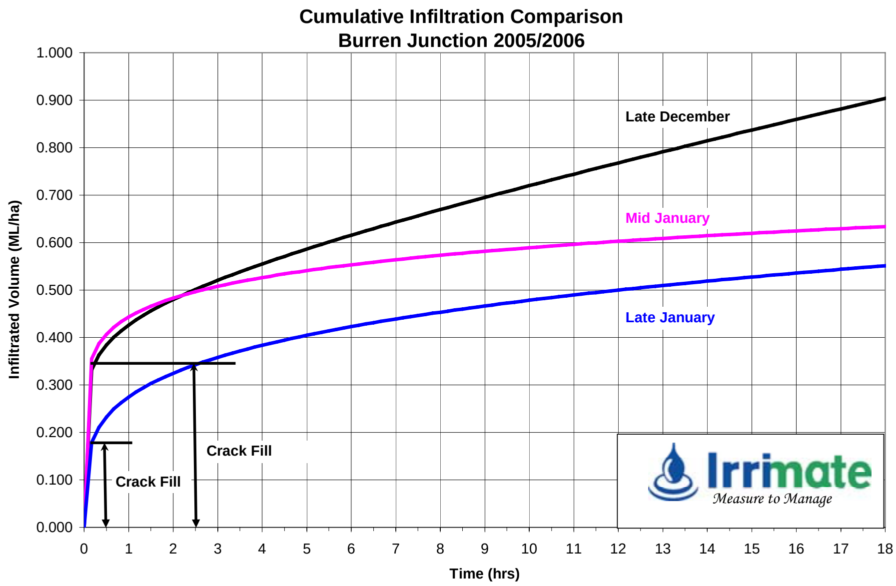


Figure 4a. Cumulative infiltration for Burren Junction, December and January irrigations

A higher rate of infiltration was measured on the lighter clay loam soil at Boggabri which shows that up to 75mm rapidly infiltrates in the first few hours of irrigation (Figure 4b). A similar rate of infiltration was measured by the Irrimate Seepage & Evaporation meter which recorded seepage rates of 16mm/day. As this site is irrigated primarily from bores, the rate of supply is one limitation to increasing the rate of water application. Increases in irrigation efficiency and reductions in water use are possible by increasing the siphon flow rate, or by providing a consistent and steeper field slope. The infiltration characteristics calculated by Irrimate indicate this site may be a good candidate for an overhead irrigator.

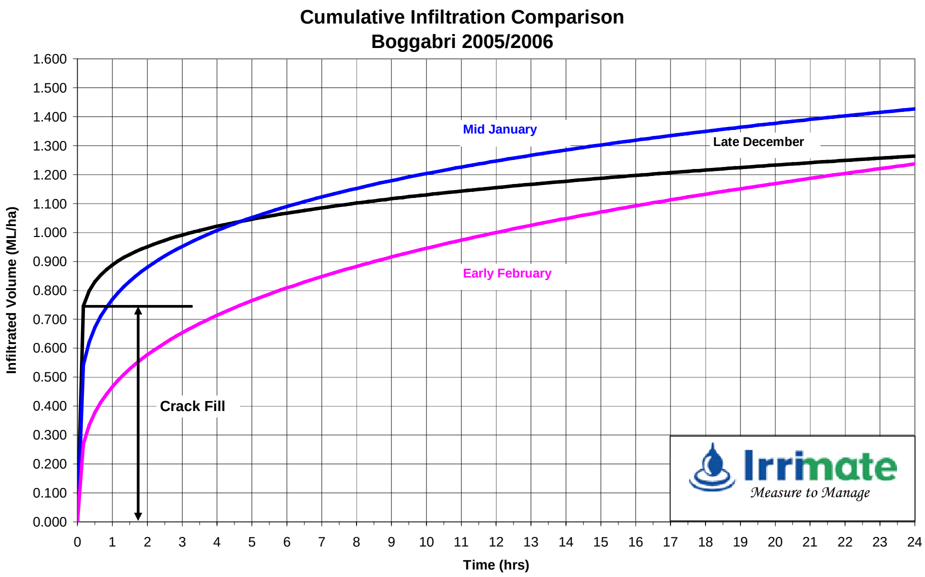


Figure 4b. Cumulative infiltration for Boggabri, December, January and February irrigations

Decision compromises

As the season has progressed and leading up to irrigation events, crop information about the soil moisture deficit, leaf area and fruit numbers have been entered into HydroLOGIC and a range of scenarios investigated. In this particular trial, a range of scenarios were assessed at each run date which has included the following combinations:

- a single irrigation deficit,
- a deficit range from 60mm to 130mm,
- change deficit scenarios from 60mm to 130mm in 10mm increments, using 2 change dates in the future (for example an initial deficit of 70mm changing to a 90mm deficit used after the 15th of January).

Determining the best irrigation date for the optimised treatment then involved reviewing the HydroLOGIC summary reports and selecting a range of scenarios with the highest average yields and favourable 'upside' risk. Through discussion with the grower, the preferred scenarios were selected, taking into consideration the total number of irrigations predicted, the timing of this irrigation with the remainder of the field, and the whole farm irrigation rotation (Figure 5).

Summary Table

Farm: Waverley
Field: Field 52
Crop: 2005-06(Sown: 24/09/2005)

Scenario: 80 to 100 30th Jan — Two Irrigation Deficits

Run date:	03/01/2006	Estimated water remaining at run date		
Pre-irrigation/water up	/ /	River:	10.0	ML/ha
Last irrigation	15/03/2006	Bore:	0.0	ML/ha
Deficit to irrigate	80mm-->30/01/2006-->100mm	Storage:	0.0	ML/ha
Irrigation efficiency	60 %		10.0	
Use future weather from	BURREN JUNCTION			
Use rainfall from	Farm			
Assume rainfall after run date:	No			

Status @ 03/01/2006		Status @ end of season	Avg	30 %	70 %
Total irrigations	2	Total irrigations	6	6	6
Water pumped (ML/ha)	3.0	Estimated yield (Bales/ha)	11.26	10.63	11.96
Water left (ML/ha)	10.0	Water pumped (ML/ha)	8.96	8.81	9.06
Squares (/m2)	154	Water use efficiency (kg lint/mm)	3.32	3.13	3.50
Green bolls (/m2)	93	60% open (Maturity)	27/02/2006	24/02/2006	02/03/2006
Open bolls (/m2)	0	Open bolls (/m2)	157.7	151.4	163.4
% open bolls	0				

Irrigation Summary

Date	Deficit at irrigation (mm)	Water pumped (ML/ha)
09/12/2005	76	1.33
27/12/2005	90	1.65
05/01/2006	85	1.42
15/01/2006	85	1.42
26/01/2006	87	1.46
05/02/2006	101	1.68

Next Irrigation...

Average			30 % (7.0 out of 10 years)			70 % (3.0 out of 10 years)		
05/01/2006	85 mm	1.42 ML/ha	05/01/2006	83 mm	1.38 ML/ha	05/01/2006	87 mm	1.45 ML/ha

Figure 5. An example of the scenario summary report showing the next irrigation date

The decision to assess such a large number of scheduling possibilities was taken following discussions with the growers involved. The simpler and more common approach would be to use a single deficit range scenario prior to each irrigation decision. This would produce a simple report showing the impact on yield of a range of deficits and the next irrigation date.

Seeking further information?

If you would like to find out more about these trials please contact Mr Dirk Richards, CSIRO Plant Industry, on 02 6799 1500, or Mr Andrew Murray, Aquatech Consulting, on 02 6792 1265.

Information on HydroLOGIC and Irrimate™ can be found in WATERpak - a guide for irrigation management in cotton, published by the Cotton Research and Development Corporation, and the Australian Cotton CRC. This publication and other Cotton CRC information resources can be found at http://www.cotton.crc.org.au/Publicat/Water/index.htm.
Specific details on WaterTrack™ can be found at http://www.watertrack.com.au/

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