Cotton
RESEARCH & DEVELOPMENT

Annual, Progress and Final Reports

REPORTS

Part 1 - Summary Details

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

CRDC Project Number: **CSP157C**

Final Report: ☒ Due 30-September 2004
(or within 3 months of completion of project)

Project Title: Integrated farm water management for cotton production.

Project Commencement Date: 1.7.03 **Project Completion Date:** 30.6.06

Research Program: 4 Farming Systems

Part 2 – Contact Details

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Signature of Research Provider Representative:

Part 3.3 – Final Reports (due 3 months after completion of project)

(The points below are to be used as a guideline when completing your final report. Postgraduates please note the instructions outlined at the end of this Section.)

1. Outline the background to the project.

Water continues to be a major constraint for cotton production systems. There is increasing pressure to improve the water use efficiency (WUE), especially of the furrow irrigation systems used by the majority of cotton growers. Farming systems, stubble management, furrow length and slope and the flow rates are all components of the system that can be manipulated to achieve higher application and distribution efficiencies under furrow irrigation.

Previous work has shown that there is significant room for improvement in both crop water use efficiency and whole farm irrigation efficiency within the cotton production system. Crop water use efficiency (CWUE) was shown to vary between 1.8kg/ha/mm and 3.2kg/ha/mm. Whole farm irrigation efficiency was shown to vary between 20 % and 80 % with an overall average of 57 %. A key approach to improving whole farm WUE is to develop an integrated approach to water management, particularly to identify factors contributing toward high crop WUE and irrigation efficiency. In addition to irrigation, in-season rainfall and stored soil moisture contribute to meeting the crop water requirement. Strategies should be developed to maximise the use of water from in-season rainfall and stored soil moisture and to improve irrigation efficiency. This will benefit the industry by saving irrigation water and enhancing the efficiency with which water is used.

2. List the project objectives and the extent to which these have been achieved.

Dr Sunil Tennakoon, the scientist working on this project resigned in October 2003 to take up a position elsewhere. Further, reductions in funding resulted in modification to the project objectives, as agreed with CRDC (see letter from Jim Peacock to Bridget Jackson in July 2003). Since Dr Tennakoon's departure most of the objectives of this project have been achieved, although at a less intensive level. This has been done by incorporation of the objectives through sharing of experiments with those of Mr Dirk Richards. Mr Richards has also agreed to and has been taking the measurements required, including skip row treatments for Phil Goyne of DPI.

Objective 1. *Evaluate the impact of skip row irrigation on application efficiency, distribution uniformity (the degree of uniformity in the amount of water infiltrated into the soil profile across the field) and crop water use efficiency.* Components of this objective were achieved by integrating this question into a large-scale experiment of Mr Dirk Richards and Mr Grant Roberts. Casual assistance was employed to take the appropriate measurements and supervision was being provided by Mr Richards. This trial was established at the CSIRO lease block 'Leitches' at Myall Vale.

The trial site was sown with Sicot 189 on the 21st of October and watered-up. With the exception of irrigation timing and allocation, the crop was grown and managed under normal cultural conditions. The timing of irrigations was determined using HydroLOGIC, with the skip row treatment being allocated 2ML/ha for the season or effectively one in-crop irrigation only. Following irrigations, the total water applied to each treatment and the in-field application efficiency was estimated. The soil moisture deficit at sowing was 104mm, however during the water-up event over 2ML/ha was applied to the field. This indicated that

a considerable amount of applied water (99mm) percolated below the rooting zone, due in part to the large cracks in the dry soil, which did not close immediately.

Tail water of 0.9ML/ha was also recorded during this event. As a consequence, the application efficiency for this particular irrigation was only 36%. Total water applied in the skip treatment for the season was 3.49ML/ha, with an estimated application efficiency of 58%. Final yield was 5.4 bales/ha and an irrigation water use index of 1.6 bales/applied ML was calculated. Soil moisture was monitored in the plant line and centre of skip positions, with extraction information recorded. An extract of this data is shown below (Figure 1) from sowing until mid January, where little extraction is occurring from the skip. This analysis is continuing and may contribute to the development of the OZCOT crop model in the future.

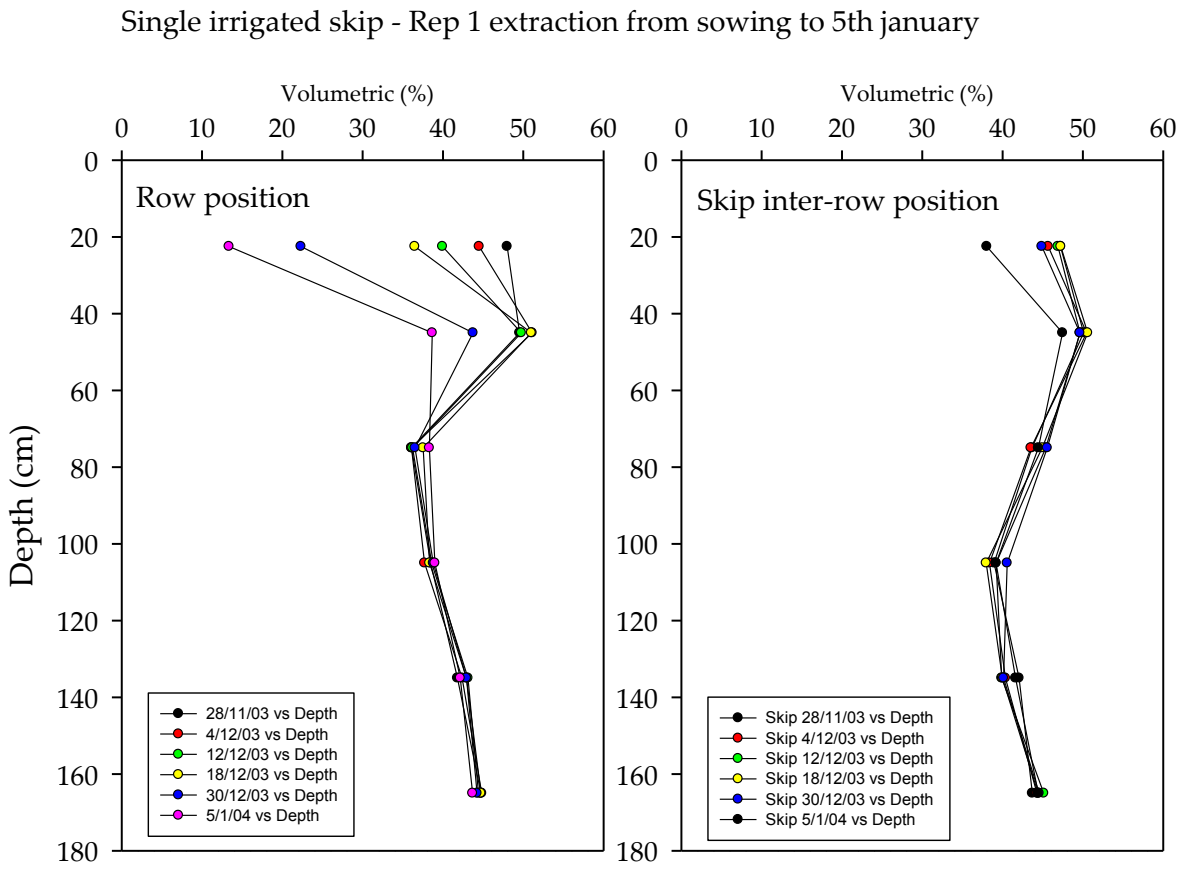

Figure 1. Water extraction for various dates in skip row cotton, with measurement take from neutron probes in the plant line (row position) or in the skip row (skip inter-row position. There was little extraction from the skip area.

Objective 2. *Modify and improve water use efficiency calculator as a tool for growers to record water management data and analyse and assess their own water use efficiencies*. The functionality of the Water Use Efficiency Calculator is being integrated into HydroLOGIC. This has the benefit that one package that can do both irrigation management and WUE recording and analysis. It also provides the opportunity to use the OZCOT model to estimate evapotranspiration, which is likely to be more accurate that simpler methods. HydroLOGIC Version 1.1.0 allows the user to benchmark the water use efficiency of individual fields. As this process proceeds the Water Use Efficiency Calculator in HydroLOGIC will be gradually enhanced, taking into account grower feedback on the earlier version. Discussions with the cotton water extension team and several commercial companies are underway with regards to the further development of HydroLOGIC to accommodate full on-farm water accounting.

As an addition to this work the CRDC approached CSIRO about the possibility to re-visit the sites that Dr Sunil Tennakoon originally visited as part of his WUE benchmarking project. Due to the departure of Dr Tennakoon and reduced funding CSIRO was unable to undertake this task but have worked with CRDC to develop a strategy to complete it. Mr Mitch Carter (NSW DPI) will undertake to visit and re-survey these growers and with input from Dirk Richards and Stephen Yeates will calculate the WUE estimates for comparison with the earlier study.

Objective 3. *Calibrate the Penman-Monteith equation for estimating evapotranspiration (ET) in eastern Australian cotton growing areas and assess its usefulness for on-farm estimation of evapotranspiration*. We have ensured that data collected as part of objective 1 is suitable for calibrating and testing the Penman-Monteith equation. As described below we envisage that analysis of this information will become one of the areas of responsibility for Mr Stephen Yeates when he assumes responsibility for several of the goals of this project.

Objective 4. *Continue monitoring existing farming systems experiments at ACRI to assess the water use efficiency of different cropping systems including stubble retention.* Due to the limitations in staffing we have been unable to continue research with Dr Nilantha Hulugalle into this objective this season. Dirk Richards, Mike Bange and Stephen Yeates have picked up this objective as part of another CRDC project. Elements of water use efficiency in stubble systems were be determined in the farming systems trial conducted by Mr Dirk Richards and Mr Grant Roberts in the 2003-04 season.

This trial was established at the CSIRO lease,' Leitches', at ACRI and was sown with Sicot 189 and Bollgard II® 289 on the 21st of October and watered-up. With the exception of irrigation timing and allocation, the crop was grown and managed under normal cultural conditions. Three different water allocation treatments were imposed; 8ML/ha, 4ML/ha, and 2ML/ha, with timing of irrigations determined individually using HydroLOGIC. Each treatment was replicated three times.

Soil moisture and nitrogen were determined prior to sowing. Plant sampling and neutron probes were used during the season to determine fruit numbers and soil moisture deficit. During the watering up event, the wheat stubble treatment required twice the amount of water compared with the conventional. The wheat stubble treatment had faster growth than the conventional initially however moisture stress was apparent by late January. Subsequent irrigation application duration and amounts were higher in the wheat stubble treatments when compared to the conventional cultivated area. Combined with heavy rainfall immediately after irrigation this led to severe waterlogging in the wheat stubble treatment. The cumulative impact of the initial moisture stress and waterlogging was a lower yield. As a consequence the final water use indices are considerably lower in the Bollgard II® x stubble treatments (Figure 2).

This strongly supports the benefits of retained stubble systems but highlights the need for careful management to avoid water logging. This could include cleaning out the inter-row area to reduce the restriction to water flow down the furrow, though leaving several metres at the end of the furrow to reduce sediment loss (Hulugalle pers comm.). The trial also had a single skip planted treatment for comparison, which compared favourably with the other treatments, achieving 5.4 bales/ha and 1.6 bales/applied ML.

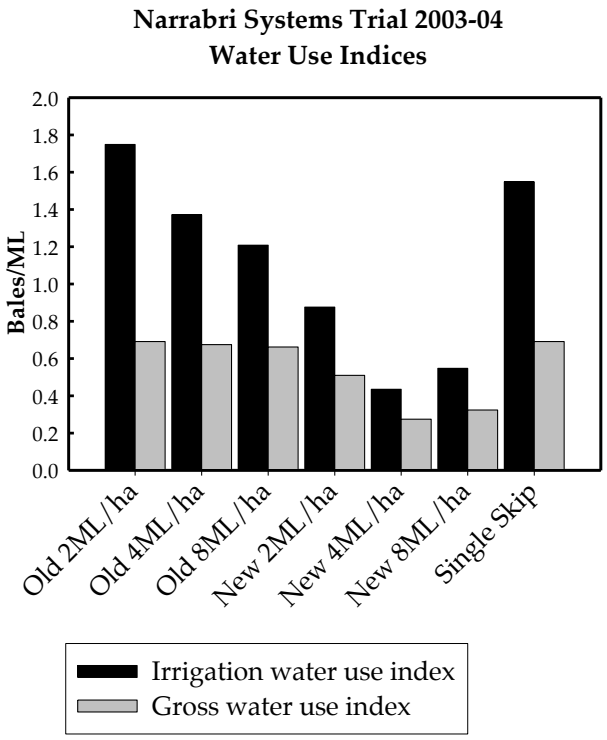

Figure 2. Irrigation water use index (irrigation water use efficiency) and gross water use index (agronomic water use efficiency) for cotton grown under the old system (no-HydroLOGIC, conventional cotton) and new system (HydroLOGIC, Bollgard II, Roundup Ready, retained stubble). The retained stubble treatments were water stress early in the season and water logged later due to heavy rain following irrigation. This reduced yield which in turn led to reduced water use indexes.

For 2003/04, components of the water balance in vetch rotation systems were studied in Dr Rochester's experiments. Soil moisture has been monitored over the last 3 years using neutron probe and C-probes, with differences in water extraction under cotton being noted between continuous cotton and the cotton-vetch rotation. Previous studies by Dr Ian Rochester have shown improvements in soil structure and potential water infiltration rates in the cotton-vetch system.

The 2003-04 season results are shown below, which indicate the differences in rates of extraction and water holding capacity. During winter 2004, soil characterisation sites were established in both treatments to quantify the differences in water holding capacity. Continuous soil moisture monitoring in 2003-04 found up to 4mm improvement in water holding capacity in the cotton-vetch treatments, although the rate of plant extraction did not vary significantly between the two systems. This analysis is continuing. It is envisaged that much of this research will continue under the CRDC project CSP164C 'Delivering science to agribusiness: smart approaches to cotton irrigation management'.

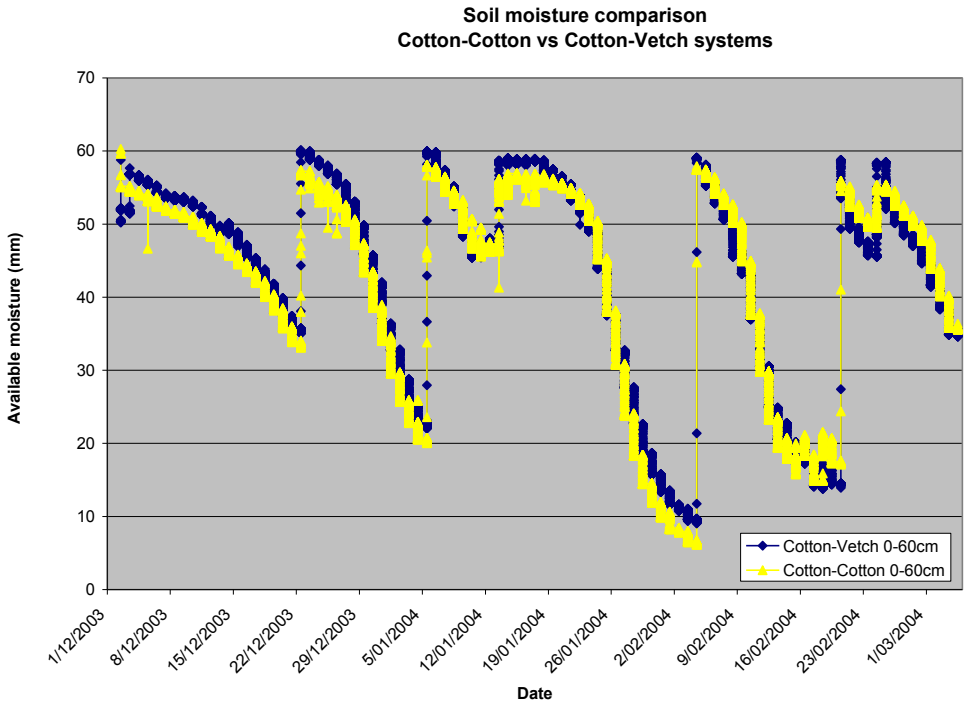

Figure 3. Water extraction from continuous cotton and cotton vetch rotation showing slightly higher water holding capacity of soils after vetch.

3. Provide a conclusion as to research outcomes compared with objectives. What are the "take home messages"?

The departure of Dr Tennakoon caused us to review our research effort in the area of Water and water management research. CSIRO Plant Industry is committed to a major effort toward improving water use in the cotton industry. With changes in staff our water group is being reorganised slightly. It will consist of Stephen Yeates, who will lead the scientific development of the group, Dirk Richards who will lead the extension and application issues, especially for HydroLOGIC, and James Neilson, who is doing research on plant water relations. In reviewing this group it is evident that there is a shortage of technical support, with only a portion of a TO shared between them. This is a severe limitation given the extensive fieldwork that is required. We therefore have suggested to CRDC that Dr Tennakoon's position be replaced with a Technical Officer under the direction of Mr Yeates. Discussion with CRDC however suggested that this might best occur by ceasing this project, and including the TO as a component of a new submission to CRDC from Dr Mike Bange, Mr Richards and Mr Yeates ' Delivering science to agribusiness: Smart approaches to cotton irrigation management. This new project will pick-up all of the objectives of CSP157C.

For this project the take home messages are:

1. More work is required to understand extraction of water under skip row cotton.
2. HydroLOGIC includes the water use efficiency calculator and this feature will be enhanced in later versions. The capacity for HydroLOGIC to account for whole farm water use is an enhancement in progress

3. Data have been collected to validate the Penman-Monteith equation and this will be completed in future.
4. Retained stubble systems offer benefits in terms of reduced loss of sediment, improved water infiltration and better early season growth. However this may be countered by the need for careful management to avoid water logging, though there are strategies to do this.
5. Investigation of the effects of vetch rotations on irrigation and water use showed slightly enhanced water holding capacity of soils following vetch rotations.
6. Resurveying the growers involved in the initial WUE Benchmarking study has been planned out and surveying will be done by Mitch Carter (NSW DPI)

4. Detail how your research has addressed the Corporation's three Outputs - Economic, Environmental and Social?

This project has been of necessity short, however information obtained will be used to improve our understanding of the relationship between agronomic management and WUE, to improve accounting of water on farm and to improve the OZCOT model that forms the basis for HydroLOGIC. Improved WUE will enhance to the sustainability of cotton production, thereby addressing economic outputs, will make more effective use of extractions from rivers and bores, thereby addressing environmental outputs and will contribute to the long term viability of irrigated cotton production, addressing the social outputs.

5. Future Research

The advent of Bollgard II has placed a new pressure on optimisation of irrigation management and WUE. This is because such crops have the potential to retain a high proportion of fruit early in the season. This may create a high burden for the plant, and the drain on resources to meet the demands of developing bolls could cause premature cut-out. Optimisation of irrigation to avoid water stress especially during the early fruit set period may enable plants to continue to grow and retain fruit. It this leads to enhanced yields or saved irrigation at the end of the season then WUE may increase. Mr Yeates will investigate this topic.

Part 4 – Final Report Executive Summary

Water continues to be a major constraint for cotton production systems. There is increasing pressure to improve the water use efficiency (WUE), especially of the furrow irrigation systems used by the majority of cotton growers. Farming systems, stubble management, furrow length and slope and the flow rates are all components of the system that can be manipulated to achieve higher application and distribution efficiencies under furrow irrigation.

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1. More work is required to understand extraction of water under skip row cotton.
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4. Retained stubble systems offer benefits in terms of reduced loss of sediment, improved water infiltration and better early season growth. However this may be countered by the need for careful management to avoid water logging, though there are strategies to do this.
5. Investigation of the effects of vetch rotations on irrigation and water use showed slightly enhanced water holding capacity of soils following vetch rotations.
6. Resurveying the growers involved in the initial WUE Benchmarking study has been planned out and surveying will be done by Mitch Carter (NSW DPI)

The core goals of this project have now been included in CSP164C.