The Future Direction of On-farm Irrigation Technologies and Practice Research

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Abstract
The Cooperative Research Centre for Irrigation Futures mission is to facilitate cooperative research and training networks and programs which continuously improve irrigation policy, tools, practices and processes. This paper provides an introduction to the current and planned research activities within the CRCIF with a particular focus on the tools and practices of relevance to improving on-farm water use efficiency. A key focus of this research is the delivery of research outcomes via toolkits which enhance the irrigation sector's ability to measure, monitor and manage the water balance at the field and farm scales, improve the precision of in-field irrigation applications and maximize agronomic responses to irrigation.

Introduction

The Cooperative Research Centre for Irrigation Futures (CRCIF) was established in July 2003 with a mission to facilitate cooperative research and training networks and programs which continuously improve irrigation policy, tools, practices and processes to: double irrigation water use efficiency; improve profitability for commercial irrigation enterprises; and protect and enhance our landscapes and environment. It is an unincorporated joint venture encompassing 14 partner organisations including the NSW and Victorian Departments of Primary Industries, Queensland Department of Natural Resources and Mines, CSIRO Land and Water, Goulburn-Murray Water, Sunwater and the Universities of Southern Queensland (through the National Centre for Engineering in Agriculture), New England, Western Sydney, Melbourne, South Australia and Charles Sturt University. The CRCIF is not an extension or adoption agency. Rather, the CRCIF is focused on delivering outcomes in partnership with existing private (e.g consultants) and public sector providers.

The CRCIF has a two-phase investment program. The first phase runs for three years and is focused on delivering on existing knowledge, scoping opportunities for future exploration and building the sound collaborative partnerships that will represent our most important legacy. During this period of investment, the CRCIF has operated with three program areas. The "Policy and Planning for Change" program is exploring the social, economic, legal and planning innovations needed to assist in the transition to future sustainability on a farm, catchment and regional scale where as the "Sustainability" program is investigating the characteristics of a sustainable irrigation system in a catchment context by developing knowledge to enable more efficient use of resources and to reduce the impact on the environment. The "Future Irrigation Technology and Practice" program is focused on the development and promotion of new irrigation methods, technologies and systems in rural and urban environments.

The second phase of investment will run for four years starting in mid-2006. It will have only two programs of activity: The "System Harmonisation" program will provide a mechanism by which the irrigation industry can examine its current extraction patterns in light of a holistic review of surface and ground water resources and attempt to find alternative demand management strategies which may result in improved productive performance while

delivering an environmental dividend. The "Toolkits for improved irrigation practice at the enterprise level" program will provide the basis for improved on-farm volumetric and agronomic water use efficiencies. This various components of this program are discussed in more detail below.

Current CRCIF Technologies and Practice Research

While the CRCIF has only been operating for two years, its partner organisations have been providing research and development outcomes in partnership with industry for much longer. Example within the cotton industry include the National Centre for Engineering in Agriculture (NCEA) involvement in the development of the Irrimate™ range of surface irrigation performance evaluation services on-farm storage monitoring tools and the on-going research supporting the implementation of large mobile irrigation machines. Hence, the initial CRCIF efforts have been building on these existing activities by creating collaborative linkages, identifying a shared vision between partners of priority research opportunities and assisting with the delivery of existing sector funded research. Other major outputs to date include:

- The second edition of the "Soil Moisture Monitoring Guide" published.
- Grid of national potential evapotranspiration values produced and available from the SILO web site.
- Sensitivity analysis of input data used in national evapotranspiration grid conducted and highlighted errors of up to 1 mm/day due to use of default wind speed values.
- Water, nutrient and salt balance study identified that irrigation and nutrition management principles used by open hydroponics systems can be efficient if managed appropriately.
- Risk analysis of open hydroponic systems identified concerns with: water supply capacities, nutrient leaching, root zone salinity and sodicity issues, and boron toxicities.
- Publications on "Soil-water and salt movement associated with precision irrigation systems", "Improving plants water use efficiency and potential impacts from soil structure change" and "Smart systems and system harmonisation" released.
- Barriers to the adoption of measurement technologies for precision irrigation identified
- Scoping studies on technology gaps and research opportunities in (i) measurement and monitoring tools and (ii) application system performance completed.
- Opportunities for working across regions and crops by linking available software to manage on-farm water identified.

Future Directions – Toolkits for improved irrigation practice at the enterprise level

The CRCIF "Toolkits for improved irrigation practice at the enterprise level" program is currently being developed and will start in mid-2006. However, planning within this program recognises that significant incremental improvements across all sectors have already been achieved and will continue to be achieved through the effective engagement of professional support personnel and best management practice programs. Much of these improvements are being driven by the adoption of existing technology and proven practices. This program will where necessary repackage and promote these tools to meet new and existing user defined needs. However, in order to achieve the quantum leaps in irrigation practice which the CRC IF believes are possible and necessary within the rapidly changing legislative and biophysical environment in which we now operate it is necessary to generate a range of new tools.

A common priority in evaluating new tools is the need to focus on technologies and practices for which drivers are either existing or imminent and to ensure that the developmental process includes a knowledge exchange interface appropriate for the targeted end user. There is also a

need to look for shared investment from industry which will only be achieved by focusing on deliverables. This will require an increased awareness of the drivers for adoption, recognition of the social, regulatory & economic factors modifying the likely responses and an improved targeting of knowledge interfaces. The CRCIF research and development effort at the enterprise level will focus on four leading edge areas of research (Figure 1) which if successfully implemented will lead to dramatic improvements in irrigation performance. The new products and tools developed in these areas of research will be incorporated into system specific "Toolkits" which support effective utilization by end-users (growers, advisors and consultants) and which may involve commercial arrangements with private or public sector delivery organisations.

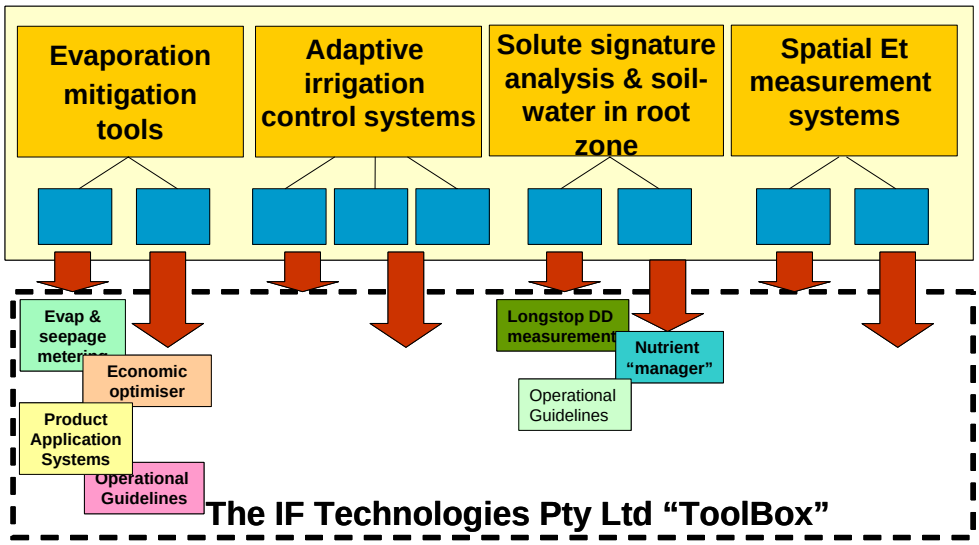

Figure 1: Structure of the CRCIF "Toolkits for improving practice at the enterprise level" program

Confirmation of Evaporation Mitigation Technology on Large Dams:
Current work clearly demonstrates the practical and economic advantage associated with the use of a range of full cover technologies on small dams (1-5 ha) in high value horticultural endeavours. Although adoption of these technologies will have a significant financial benefit to individual organisations and a potentially large impact on regional economies they are unlikely to result in the generation of significant quantities of water on a system wide scale.

Mono-layers are the only technology currently capable of reducing the evaporative losses from large farm and scheme storages. However, previous evaluations have demonstrated that the benefits of monolayers are significant but variable depending on operating conditions and management practice. In order to resolve the performance related issues associated with this technology and to develop the application and management strategies necessary to optimise its use on large storages there are a number of critical theoretical questions yet to be resolved:

- How to measure evaporation losses spatially across the surface of a storage?
- How to evaluate the rate of product biological and physical breakdown rates in the field?
- How to establish a real time performance monitoring loop linked to product application rate? and

- What are the appropriate technology mixes (including mono-layer application systems) and physical infrastructure which deliver optimized and cost effective performance?

These questions will be examined in the light of the new technologies being established in spatial evapo-transpiration measurement systems.

Adaptive Irrigation Control Systems

Irrigation scheduling is predominantly managed through analysis of volumetric soil water data. However, the concept of using plant based indicators to directly monitor plant water status and control irrigation application provides opportunities for both the spatial assessment of irrigation demand and better targeting of irrigation applications during specific phenological phases. New technology in both drip, spray and surface irrigation provide an opportunity for much greater control of the actual irrigation event allowing greater input of real-time plant response data to the water application management.

Technology is available in the horticultural industries for point based measurement of plant responses to irrigation such as sap flow and trunk diameter. The project will examine novel ways in which these sensor sets can be linked by advanced communication networks to better manage real time plan water requirements.

In addition this project will target the development of a range of existing low cost broad acre sensor technologies including NDVI from aerial imagery and remote sensed data to achieve a useful set of input control data as well as evaluation of some new sensor technologies (eg. vision measurement systems) to create similar real-time plant response feedback loops in these environments. A key focus of this activity is the measurement of spatial and temporal variability in irrigation requirements and the development of of real time adaptive (or self learning) control systems. It is also expected that this research will link strongly with the spatial ET measurement research to enable the identification of real-time self calibrating "crop factors" for a range of crops and varieties.

Spatial Evapo-transpiration Measurement

Evapo-transpiration (ET) is the key driver of performance in all farming systems, but is of critical importance within an irrigated environment where it drives application decisions about when and how much water to apply as well as infrastructure performance in storages and distribution systems. The capacity to accurately quantify crop ET at a range of scales also provides a very real opportunity to nail down one of the key variables in the volume balance equations which continually plague practitioners in productive as well as environmental decision making arenas (eg deep drainage).

Current crop and storage ET estimation is undertaken using a range of point based measurement systems ranging from the Class A Pan – through to Eddie Correlation Equipment. There has been limited work undertaken in the use of spatial technology such as remote sensing, tunable LIDAR and scintilography. This project aims to utilize these tools in order to make spatial ET measurement a reality for real time crop performance optimisation and evaporative control experimentation.

Solute Signature Analysis and Salt Water Movement in the Root Zone

There is a vast body of research work already available in the area of soil solute movement and plant salt/water interactions. As we move toward the adoption of precision irrigation systems with consistently high volumetric water use efficiencies and increasingly utilise

saline irrigation waters we are testing the limits of this knowledge. Two tools appear to offer significant opportunity in addressing this issue from both a theoretical as well a practical point of view:

- Solute Signatures – that uses the relative change in distribution of different solutes within the soil over time to provide better measures of performance and sustainability; and
- Three dimensional models of soil-water and solute movement.

It is proposed that a combination of these tools will provide a significantly enhanced understanding of plant interactions in this environment and subsequently our capacity to manage this environment better for environmental as well as productive outcomes.

Conclusions

The CRCIF is focused on conducting research to deliver tools and practices which provide tangible on-farm improvements in both volumetric and agronomic water use efficiencies. Planning for the second phase of CRCIF research investment is currently underway and there is an increased emphasis on the delivery of outputs through both private and public sector market partnerships.