RESEARCH BULLETIN

Defining precision irrigation: A new approach to irrigation management

Summary

Despite the widespread promotion and adoption of precision agriculture in dry-land cropping systems, the concept of irrigation being part of precision agricultural systems is still getting off the ground, both in Australia and internationally. There is currently no cohesive framework available to guide research, development or adoption of precision irrigation and its associated support technologies.

This project is reviewing irrigation research, existing technologies and the use of precision irrigation. It will assess the role of current irrigation application technologies in precision irrigation, variable rate applications, adaptive control, and the sensing and decision support requirements. Opportunities for adoption and future research will also be identified. The first stage of the project - conceptualising and defining precision irrigation - is summarised in this research bulletin. Any feedback on this information would be gratefully received. The newness of precision irrigation means there has been very little discussion around the concept—and any research being conducted will certainly benefit from shared knowledge. Details for feedback are listed on the last page.

What exactly is precision irrigation?

Drip irrigation is often regarded as epitomising precise irrigation because of its ability to control application rate and timing. The traditional meaning of precise irrigation is about applying precise amounts of water to crops at precise locations (e.g. within the soil profile) and at precise times – but uniformly across the field. This traditional definition is still widely used, particularly in the commercial sector. An internet search of the term 'precision irrigation' brings up a large number of irrigation installers and equipment sales companies, particularly in the area of turf and drip irrigation installations.

Precision irrigation as a concept differs substantially from this traditional definition. For this project, we are defining precision irrigation using precision agriculture principles. Precision irrigation involves the 'differential irrigation' treatment of field variation as opposed to the 'uniform irrigation' treatment that underlies traditional irrigation management. Precision irrigation focuses on individual plants or small areas within a field, while the traditional definition takes a 'whole-field' approach. However, precision irrigation is much more than the precise application of water:

- precision irrigation is holistic, it should seamlessly combine the optimal performance of the application system with the crop, water and solute management
- precision irrigation is not a specific technology, it's a way of thinking; a systems approach
- precision irrigation is adaptive, it's a learning system
- precision irrigation is applicable to all irrigation methods and for all crops at appropriate area and time scales.

Some definitions of precision irrigation focus on variable rate technologies for pressurised irrigation systems, and particularly on centre pivots. Such definitions limit the scope and potential of precision irrigation. Variable rate technology, at a scale appropriate to the application system may be an essential component of precision irrigation.

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However, it is just one of the many tools that may be applicable when using a precision irrigation system.

Precision irrigation is a union between advanced irrigation management and sensing, simulation and control. This might lead to the perception that precision irrigation is all about using technology. This will not always be true, although with time precision irrigation is likely to incorporate advanced technologies including automation and informatics. Precision irrigation is a systems approach to optimising yields through systematic gathering and handling of information about the crop and the field, and is applicable irrespective of the sophistication of the technology employed.

Aims / Goals of a precision irrigation system

Variation in crop production within a particular field or area occurs because of differences in soil structure and fertility; irrigation applications; pests and diseases; and plant genetics. This variability can arguably be managed (therefore maximising the economic benefit from irrigation) by meeting the specific irrigation needs of individual management zones: that is a precision irrigation approach.

Precision irrigation will potentially alter on-farm decision-making, and simultaneously achieve the multiple objectives of enhancing input use efficiency, reducing environmental impacts, and increasing farm profits and product quality.

The key to a successful precision irrigation system will be defining site specific goals or objectives, which might include:

- reducing costs by applying only the optimum amount of irrigation
- minimising adverse environmental impact, and better management of the resource base
- optimizing the economic value of the water applied through irrigation
- optimizing crop production (yield quantity and/or quality)
- saving water.

Four essential steps of a precision irrigation system

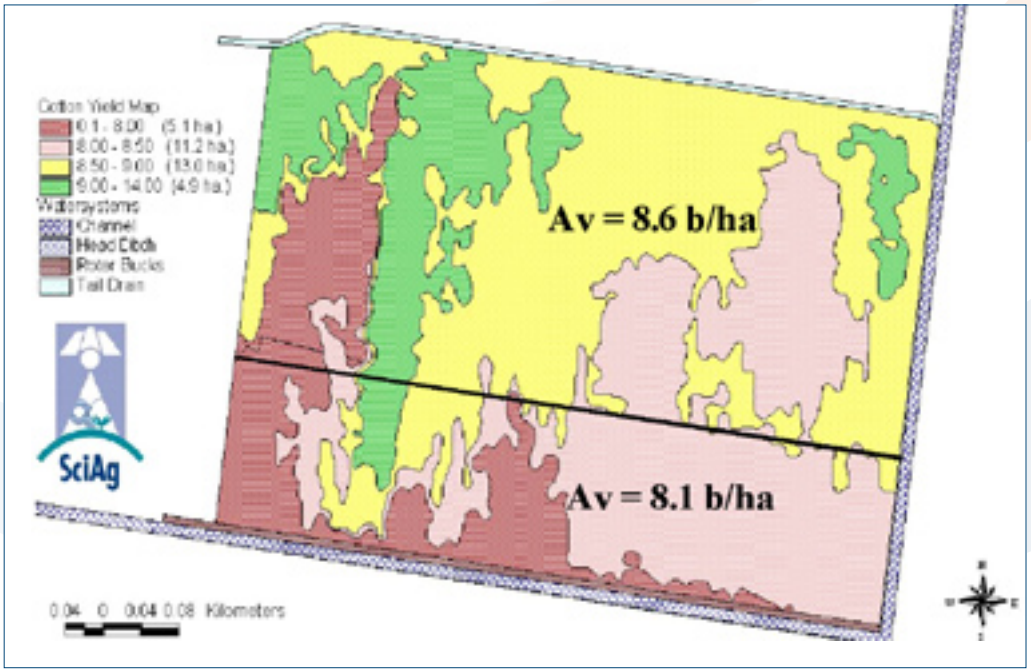
Precision irrigation is best viewed as a management approach defined by the precision farming cycle. There are four essential steps in the process and technologies required: data acquisition, interpretation, control, and evaluation.

Data acquisition

Precision irrigation systems need clear evidence of significant spatial and/or temporal variability in soil and crop conditions within a field and between fields, and the ability to identify and quantify such variability. Existing technology can measure the various components of the soil-crop-atmosphere continuum (soil based monitoring, weather based monitoring, plant sensing), many in real-time and at sub-metre scales, and can provide precise and/or real-time control of irrigation applications. The practical limitation will be the density of measurement required.

Interpretation

The data acquired has to be interpreted and analysed at an appropriate scale and frequency. The inadequate development of control and decision support systems for making precision agriculture decisions is one major stumbling block to adopting a precision agriculture approach. Appropriate multi-dimensional simulation tools (incorporating crop response, system constraints etc) are essential for optimising irrigation.



Cotton yield map illustrating variation in crop outputs across an area

Control

The ability to reallocate inputs and adjust irrigation management at appropriate temporal and spatial scales is an essential component of a precision irrigation system.

Applying different depths of water over a field will depend on the irrigation system, but can be achieved in two ways: by varying the application rate or by varying the application duration.

Automatic controllers with real time data from on-the-go sensors should provide the most reliable and potentially accurate means of controlling irrigation applications.

Evaluation

Evaluation or 'closing the loop' is an important step in the precision irrigation process. Measuring the engineering, agronomic and economic performance of the irrigation system is essential for feedback and improving the next cycle in the system.

Temporal and spatial scales

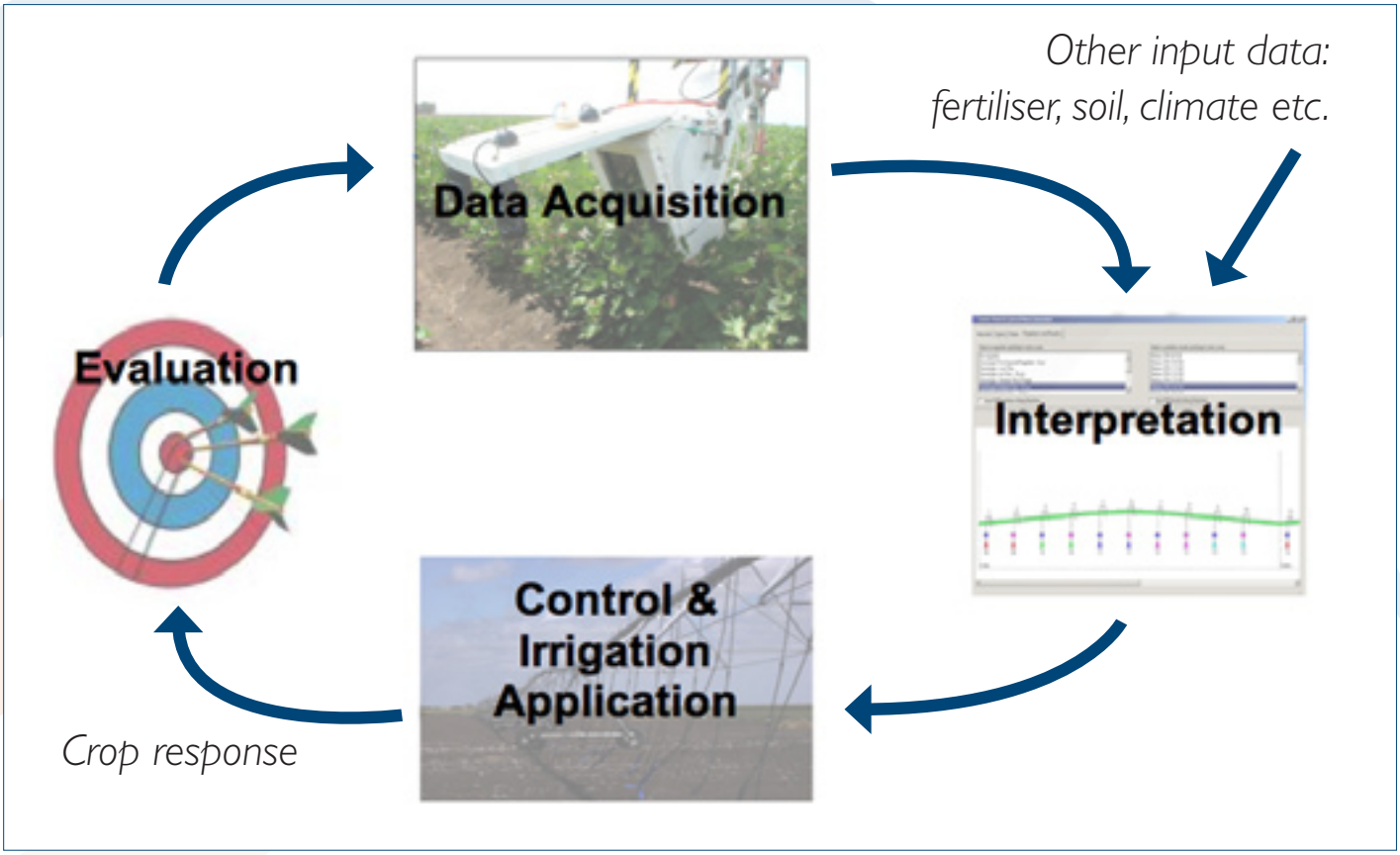
Precision irrigation can be looked at from the "tactical" or day-to-day management level to the "strategic" or seasonal management level.

At the strategic level, precision irrigation is the result of long term decision-making processes using broad scale field or farm level data over monthly, seasonal or yearly data time frames. It should be used to identify broad scale irrigation management strategies based on variations in elements such as crop/variety selection, planting area, planting dates, expected weather conditions, field layout, equipment constraints and expected economic returns.

At the tactical level, precision irrigation has a much more refined focus and, at its most precise, has an ability to alter irrigation management in real time and at the sub-metre scale. Where the capability for data collection, decision-making or control is limited in either temporal or spatial scales, the level of precision achievable is similarly limited.

Response timing can vary from: automatic – in which a real time response follows immediately after some variable quantity is measured – to temporally separate – in which the response occurs some time (possibly the next season) after the measurement and recording.

Precision Irrigation Cycle: (i) Data acquisition, (ii) Interpretation, (iii) Control and (iv) Evaluation



The spatial resolution of the precision irrigation system will be influenced by:

- the irrigation application system used (e.g. the wetted area of a single sprinkler or emitter, or a single furrow)
- limitations with data acquisition, decision support simulation capabilities etc
- the variability in the crop water requirements.

The yield variability within the whole field might also be controlled by dividing the field into compatible management zones, that is, fixed areas within a field or irrigation system where the crop response to irrigation is somewhat uniform.

Future Work

A review of the opportunities for precision irrigation in Australia is underway. The next stage of this project will:

- conceptualise how precision irrigation might be used for a range of irrigation systems (sprinkler, surface and micro), including the appropriate sensing, control and decision support requirements
- identify opportunities for and potential benefits from precision irrigation
- identify research opportunities and needs
- present a series of case studies illustrating examples of tools, technologies and practices that might form part of a precision irrigation system.

For more information contact:

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We are seeking feedback from irrigators, researchers and extension officers with experience in precision irrigation or its associated technologies. Do your irrigations vary across your fields and/or between irrigations? What tools and technologies do you use to measure and manage the variation in irrigation demand in space and/or time? What were the issues in implementing your system? What were the benefits / negatives in adopting your system? Your assistance in identifying case studies, examples, gaps, or opportunities related to the concept of precision irrigation is very welcome.

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