**NPSI/IAL Travel Fellowship 2010: site-specific irrigation control and sensing systems**

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The site-specific determination and application of irrigation requirements can make better use of available irrigation water and improve crop performance. Commercial variable-rate systems that deliver site-specific application of irrigation are available for centre pivot and lateral move irrigation machines (e.g. Design Feats, Valmont, Zimmatic). These systems adjust the irrigation by pulsing a solenoid on each dropper to achieve time proportional control (Figure 1). The irrigation is adjusted based on pre-determined maps rather than measurements of soil and crop response. The greatest limitation to the adoption of variable-rate irrigation is associated with developing optimal irrigation schedules (i.e. volume and timing of irrigation) or irrigation prescriptions.


**Figure 1**: Valmont irrigation solenoids on each dropper

## Site-specific irrigation control

More advanced methods of irrigation decision-making are being developed at the National Centre for Engineering in Agriculture to deal with spatial and temporal variability in field properties, data availability and hardware constraints. This research, funded by the Cotton Research and Development Corporation, involves the development of real-time site-specific irrigation control strategies which are robust to data input availability. The software 'VARIwise' has been created to develop and simulate site-specific irrigation control strategies (Figure 2). Control strategies developed in VARIwise are either: (i) 'sensor-based' strategies which directly adjusted the irrigation application according to the measurement response; or (ii) 'model-based' strategies which used a calibrated soil and plant model for irrigation management. These strategies are also applicable to surface irrigation by considering the application variability of irrigation water along the field. Evaluations of these strategies on cotton crops have commenced.

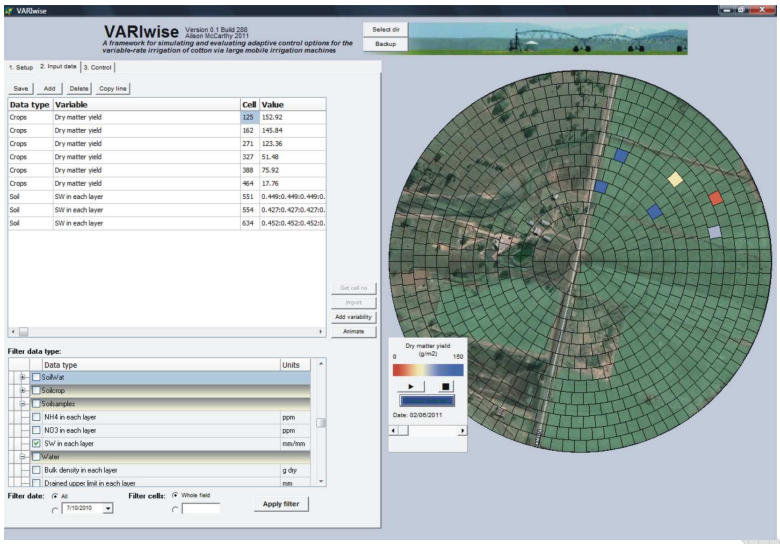


**Figure 2**: VARIwise software for site-specific irrigation

## Current state of control and sensing systems in the US

The NPSI/IAL Travel Fellowship 2010 aimed to investigate the state of sensor and control system development for site-specific irrigation. Control strategy development can often be driven by the available sensor technology, but it is likely that control strategy options also drive future plant and soil moisture sensor development. A study tour of six universities and US Department of Agriculture – Agricultural Research Service (USDA-ARS) stations, and two commercial variable-rate irrigation companies in the USA was conducted in March 2011.

Jake LaRue, Project Manager of Valmont Irrigation, acknowledged that the adoption rate of variable-rate irrigation is poor and that growers with the systems are not continuing to use them for variable-rate irrigation, e.g. only four out of 100 growers who purchased Farmscan systems in Georgia, USA in the previous five years are still using the variable-rate technology. To help overcome this, Valmont Irrigation now offers an additional system 'CropMetrics' to develop irrigation prescription maps. The irrigation prescription maps are based on EM38 and topography maps, and measurements from one soil moisture content sensor in the field. Funding cuts in irrigation research in the US have limited the use of variable-rate technology at USDA-ARS stations to research tools for testing different crop varieties and nutrient levels.

The sensors used for irrigation decision-making at the research stations visited were typically weather, soil moisture and infrared thermometers. Sensors were being developed at Washington State University using cameras to measure crop structure and growth from images. Such sensors could be developed with application to site-specific irrigation control systems as feedback of crop stage in model-based control strategies. Infrared thermometry was used to initiate irrigation events when the temperature of the crop exceeded a set level for a set number of minutes. Arrays of infrared thermometers were either mounted on a centre pivot to collect data as the irrigation machine traversed the field (Figure 3) or installed at fixed locations in the field.

**Figure 3**: Three infrared thermometers on centre pivot irrigation in USDA-ARS at Bushland, Texas

Model-based irrigation control strategies were being developed at many USDA-ARS stations to determine irrigation application. These involved using measured weather, soil and plant information to calibrate a crop model, and then running the model with a range of irrigation applications and timings to determine the optimal combination to achieve a set soil moisture deficit. The models used in model-based strategies were different at each research station visited and each model may have different sensor requirements for model calibration.

**Lessons for site-specific irrigation in Australia**

- It is clear that to be successful the design of variable-rate irrigation control systems needs to be holistic, i.e. achieve the integration of appropriate sensors, control strategies and variable-rate hardware.
- Irrigation control systems should have low data requirements to be adopted more readily. It is anticipated that sensor-based strategies or strategies with simple data inputs would be adopted before model-based strategies which have more extensive data requirements. A more integrated approach to model-based control strategy development will reduce the overlap in their development with each research station developing strategies using different models.
- The use of infrared thermometers to irrigation control should be considered.
- Control strategy requirements should be the drivers of future plant and soil moisture sensor development.
- The further development of sensors for model-based irrigation control strategies should include camera-based plant sensors, which can provide useful visual information on plant water and growth status.