Sharp, J.M. & Brown, H.E., 2016. Application of a Systems Model to Spatially Complex Irrigated Agricultural Systems (Eds L.D. Currie and R.Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 29. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. 3 pages.

APPLICATION OF A SYSTEMS MODEL TO SPATIALLY COMPLEX IRRIGATED AGRICULTURAL SYSTEMS

Joanna Sharp & Hamish Brown

Systems Modelling Team, Sustainable Production Portfolio, The New Zealand Institute for Plant & Food Research Limited, Private Bag 4704, Christchurch 8140, New Zealand.
E-mail: joanna.sharp@plantandfood.co.nz

Introduction

Although New Zealand (NZ) is water-rich, many of the intensively farmed lowland areas suffer frequent summer droughts. Irrigation schemes have been developed to move water from rivers and aquifers to support agricultural production. This saw a 70% increase, to 750,000 ha, in irrigated land from 2002 to 2010 (Statistics NZ 2010). The production and economic benefits are substantial, and in the summer of 2011/12 irrigation contributed $NZD 2.17 billion to GDP (NZIER 2014). The NZ Government is also investing a further $NZD 435 million to encourage development of additional infrastructure and this is expected irrigate a further 350,000 ha by 2035 (NZIER 2014). Tools and recommendations to enable irrigation practices that improve water use efficiency (WUE), reduce run-off, drainage, and subsequent nutrient losses, are seen as essential components of achieving fresh water policy goals (MFE 2013) and maximizing returns on investment.

Lateral or centre pivot sprinklers make up 74% of irrigation systems (Statistics NZ 2010), with many adapted for variable rate irrigation (VRI). Such systems provide enhanced control of water application both spatially and temporally. To develop tools and recommendations that consider both water dynamics and profitability of these irrigated cropping systems, a framework for an existing systems model was constructed that could capture the variability in soil, cropping systems, and irrigation application observed under a single irrigator with constrained water and infrastructure availability.

Materials and Methods

The systems model used in this study was APSIM next generation (APSIM Initiative 2015), a current prototype of an updated version of the Agricultural Production Systems sIMulator (APSIM) (Holzworth et al. 2014). The model chosen is able to simulate systems that cover a range of plant, soil, climate and management interactions, while the software architecture in the updated application allows faster run times for complex simulation setups, more robust software architecture, clearer and consistent code language, and concurrent running of multiple simulations.

An advanced irrigation module was built to translate irrigator specifications into spatial and temporal application events, and a module for calculating gross margins for irrigated systems was created. To consider the multiple layers of variability in soil, crop, topography and infrastructure present under a single irrigator, a multiple patch approach was required. To do this, a set of methods was developed to create multiple patch simulations in APSIM, with patches that were spatially aware, interconnected and could run concurrently. These patches, with identifying tags, might have differing soil characteristics, crop management, slope and position under the irrigator but were controlled by overarching management routines (Fig. 1).

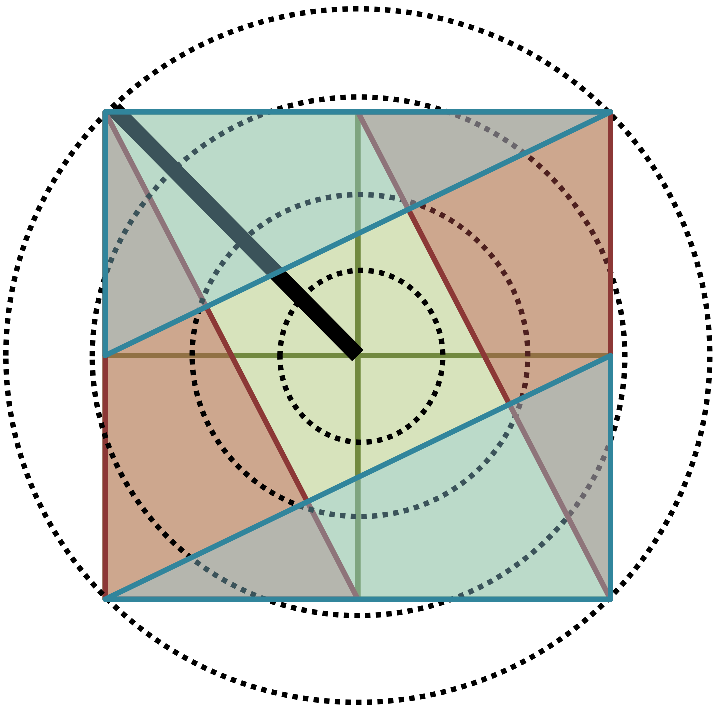

Figure 1 **Stylised collection of fields under a single irrigator indicating different soil (brown), management (green), topography (blue) and irrigator position (black) layers of information that intersect to form a patch structure.**

These routines were linked into each patch and determined application depth and timing of irrigation, as well as surface run-on/off, based on irrigator specifications, soil water, infiltration capacity, and irrigation application rate. The system developed also allowed limitations to be placed on fixed resources, such as water and infrastructure, to enable scenario analysis to be undertaken in a constrained system, and to allow outputs from the simulations, such as water applied, yield, drainage, profitability and WUE, to be mapped spatially.

Results and Discussion

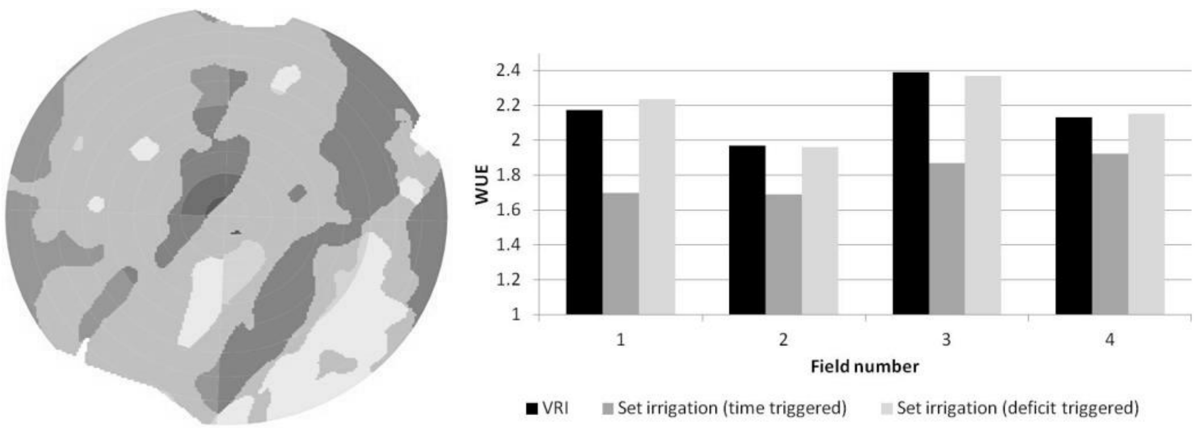

Figure 2 **Example outputs of water use efficiency (WUE) in wheat under a centre pivot irrigator with multiple irrigation strategies (VRI, triggered by elapsed time, triggered by soil water deficit), considering spatial variability in soil properties and cropping management in a ficticous test scenario.**

While still at the early application stage, the advanced irrigation module and multi-patch framework can model the water uses and profitability of different irrigation options. Figure 2 shows an example of these outputs. It shows that, given fictitious variability in soil properties, different irrigation strategies can have different water use efficiencies when matched to that variability. The system will then be used to conduct scenario analyses to determine guidelines for irrigation requirements on landscapes with differing extents of variability in soil, crop and irrigation infrastructure. This model is a useful research tool that can be used to run case studies to demonstrate the financial and environmental benefits in adopting water efficient management and irrigation techniques.

Conclusions

This work provides a useful tool to extend the application of an existing systems model to spatially complex irrigated systems.

Acknowledgements

Work was completed as part of the 'Maximising the value of irrigation' programme with principal funding from the Ministry of Business, Innovation and Employment (contract number CO9X1309) and co-funding from the Foundation for Arable Research, Horticulture New Zealand, Environment Canterbury, Hawke's Bay Regional Council and Irrigation New Zealand. The programme is led by Landcare Research, Plant & Food Research and the Foundation for Arable Research.

References

APSIM Initiative (2015) APSIM (next generation). https://www.apsim.info/Documentation/APSIM(nextgeneration).aspx

Holzworth, D., Huth, N. *et al.* (2014) APSIM – Evolution towards a new generation of agricultural systems simulation. Environmental Modeling & Software. 62:327-350.

MFE (2013) National Policy Statement for Freshwater Management 2011 http://www.mfe.govt.nz/rma/central/nps/freshwater-management.html

NZIER (2014) Value of irrigation in New Zealand. NZIER report, Wellington.