A WEB-BASED SYSTEM FOR SCHEDULING IRRIGATION IN SUGARCANE

By

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Abstract

Adoption of decision support services (DSS) based on crop growth models has been poor and yet the concept of transferring an increasing body of scientific knowledge via DSSs remains attractive. This study explores the use of the Internet and participatory action research (PAR) to develop an irrigation management service called *WaterSense* for sugarcane irrigators in Australia. *WaterSense* combines two earlier web-based DSSs, one for use of limited water and the other for scheduling abundant water. In both cases, a small number of dedicated growers and extension staff were involved in designing and conducting field experiments to test concepts that were later included in the DSSs. An optimisation procedure (‘*Caneoptimiser*’), based on the APSIM-Sugarcane model was developed for applying limited irrigation when most needed. However, the optimisation took too long to operate as a web service. Growers with abundant water prompted the development of a simple water balance technique (called ‘*WaterBalance*’) for scheduling irrigation over the Internet. Growers with limited irrigation wanted the service offered by *Caneoptimser* with the speed and format of *WaterBalance*. A new service called *WaterSense* was developed using algorithms for canopy development and soil water hydrology from *Caneoptimser* and algorithms for reference evapotranspiration and crop factors from *WaterBalance.* Adoption by those familiar with the background research has been immediate. Indications are that the combined use of the Internet, PAR and concurrent research and demonstration will open the way for the adoption of research findings in the management of irrigation and possibly other aspects of sugarcane farming. However, widespread adoption of DSSs cannot depend on participation of the intensity required for their development. Processes of adoption beyond the case study need further research.

Introduction

Over the past 25 years, a plethora of software tools has been developed for farmers but use of these tools has not grown with computer ownership as expected (McCown, 2002). Crop simulation models which often support these software tools have nevertheless been used extensively in research and education. Researchers have continued to develop and improve their models. Some attempts to transfer the knowledge encapsulated in these models to growers have been reasonably successful but many have been disappointing (McCown, 2002). In Australia, remarkably few have explored the Internet as a method of developing and applying decision support services (DSS) for irrigation management (Inman-Bamber and Attard, 2005). This paper describes *WaterSense* as such an attempt using participatory action research (PAR) to develop the scientific concepts underpinning the DSS.

Methods

WaterSense combines two earlier web-based irrigation DSSs, one for growers with limited water in the Bundaberg – Isis region of Queensland (Inman-Bamber *et al*., 2005) and the other for growers in the Ord irrigation scheme with abundant water (Webb *et al.*, 2006). In both cases a small number of growers and extension officers (EO) were involved in designing field experiments to test the concepts that were later included in these DSSs.

The issue needing most urgent attention in the Bundaberg-Isis region was when to apply limited amounts of irrigation. An optimisation procedure ('*Caneoptimiser*') based on the APSIM-Sugarcane model (Keating *et al.*, 1999) was developed for applying irrigation when most needed to limit yield loss due to water stress. Growers proposed a competition between their way of using limited water and the solution offered by *Caneoptimiser*. After three years of replicated comparative field experiments on two private farms, it was clear that *Caneoptimiser* and experienced growers scheduled irrigation in a similar manner (Inman-Bamber *et al*., 2002). Growers requested access to *Caneoptimiser* and this was provided over the Internet (Inman-Bamber *et al*., 2005).

The web pages required users to enter details such as the nearest automatic weather station (AWS), past irrigation dates and amounts, dates of planting, ratooning and harvesting, soil type and annual water allocation in ML/ha. The optimising method described by Inman-Bamber et al. (2005) selects a relative growth threshold based on the loss of yield that growers have to accept given the volume of their water allocation, climate and soil parameters. Irrigation is then scheduled to ensure that stress does not exceed this threshold which changes through the season depending on how the current climate compares with historical climate. *Caneoptimiser* required about 40 minutes to complete the optimisation for each paddock, which was unacceptably long for a web service.

Research on sugarcane growth and water use started in the Ord River Irrigation scheme in 1996. Research was based on concepts in the APSIM Sugarcane model, but the water use algorithms of APSIM were inadequate and had to be replaced by the reference evaporation (ET_0) and crop factor approach based on the Penman-Monteith equation (Allen *et al.*, 1998). Crop factors were determined by measuring crop evapotranspiration (ET_C) with the Bowen ratio energy balance technique (Inman-Bamber *et al*., 2006). Ord growers were involved in each of these developments. The possibility of a web scheduling service based on a simple water balance became apparent. The Ord EO and growers supported this idea and assisted in developing *'WaterBalance'* . Use of this new DSS was immediate among the three larger growers in the Ord (Webb *et al*., 2006).

WaterBalance, which schedules irrigation based on simple inputs of planting or ratooning date and target soil water deficit, appealed to Bundaberg growers and they asked for a service that offered the optimisation facility of *Caneoptimiser* at the speed and format of *WaterBalance*.

WaterBalance and *Caneoptimiser* were essentially combined to form a new service called '*WaterSense*'. *Caneoptimiser* (APSIM) contributed the algorithms for canopy development and soil water hydrology while *WaterBalance* contributed algorithms for ET_0 and crop factors. *WaterSense* now simulates canopy development and soil water processes programmed in APSIM-Sugarcane without requiring direct access to the APSIM model.

Results and discussion

A simulation of a crop ratooned with a trash blanket on 15 June 2005 on a Red Dermosol in Bundaberg illustrates how *WaterSense* will be used for those with limited and unlimited water (Figure 1). A grower with unlimited water will select a soil water deficit (SWD) that should not be exceeded. This SWD threshold will usually be the amount of water considered to be readily available to the plant. Irrigation is scheduled whenever this deficit is exceeded, subject to the minimum irrigation cycle of the infrastructure. The model calculates and displays a selection of parameters such as canopy ground cover, SWD at a selection of soil depths and a water stress factor (Figure 1a). Simulation continues into the future using average temperature and radiation regimes to predict the next irrigation date, assuming that no rain occurs before this date. Users are encouraged to update the schedule often to take current rainfall and other climate variables into account.

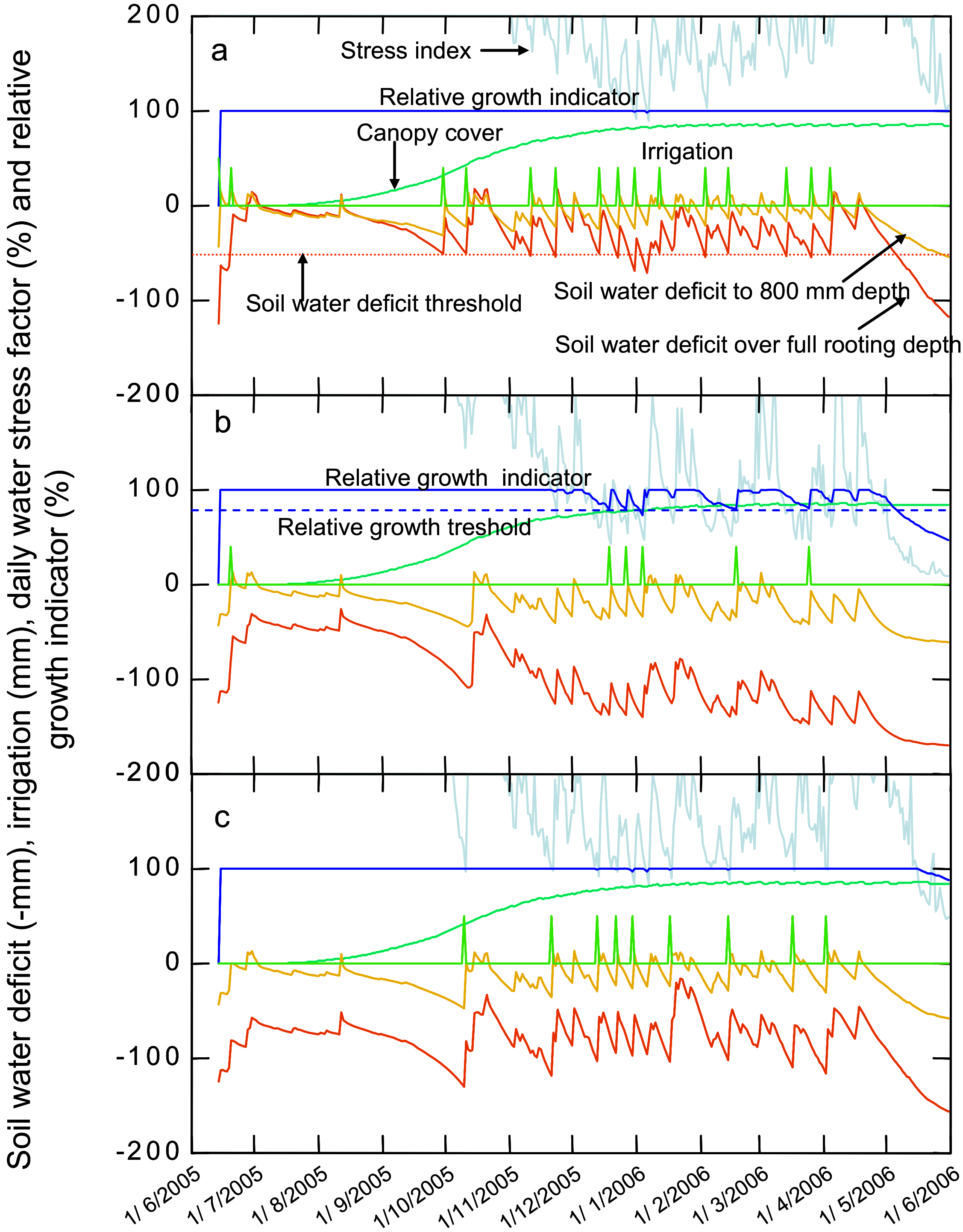

Fig. 1—Soil water deficit (–mm), irrigation (mm), daily water stress factor (%) and relative growth indicator (%) for a schedule with a) unlimited water based on SWD threshold, b) limited water based on a relative growth threshold and c) unlimited water based on achieving potential yield.

A grower with limited water cannot achieve potential yield. A target stress level needs to be selected in relation to the amount of water available, the soil type and the climate. This can be done by *Caneoptimser* or by the grower. The model will schedule an irrigation event when water stress is about to reduce yield accumulation more than the specified target value (Figure 1b).

The example in Figure 1b shows a situation where the growth threshold is 80% of potential. A relative growth indicator, which is reset after 20 mm rain plus irrigation, is displayed and irrigation is scheduled whenever this indicator crosses the selected threshold.

The optimum relative growth threshold changes only gradually during the season and can be obtained from *Caneoptimiser* when the user is offline. SWD over the full rooting depth will be greater in the limited than the unlimited scenario (Figures 1a and 1b).

The service offers the opportunity for those with unlimited water to irrigate only when necessary. This can be done by setting the relative growth threshold to 100% (Figure 1c). The model will schedule irrigations as soon as a drop in relative growth rate is imminent.

Yields for a schedule based on SWD and one based on growth rate will be similar, but the amount of irrigation could be substantially reduced for the latter scenario depending on rainfall (450 mm vs 700 mm in the example).

Summary

WaterSense has been endorsed by the BSES Limited, the Sugar Research and Development Corporation and the Cooperative Research Centre for Irrigation Futures. These organisations will continue to be involved in the further development of *WaterSense* and its adoption in the sugar and possibly other cropping industries.

Adoption by those growers familiar with the background research has been immediate. Indications are that the combined use of the Internet, PAR and concurrent research and demonstration will open the way for the adoption of research findings in the management of irrigation and possibly other aspects of sugarcane farming.

However, widespread adoption of DSSs cannot depend on participation of the intensity required for their development. The intensive involvement of growers in both the definition of the problem that *WaterSense* addresses and the specific design of the software interface will have 'embedded' much of the expert knowledge of the growers and scientists into the tool.

*WaterSens*e may therefore become a product like a new variety or soil moisture gauge with embedded technology, making it more amenable to promotion by traditional extension techniques (Jakku and Thorburn, 2007).

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UN SYSTÈME BASE SUR INTERNET POUR PLANIFIER L'IRRIGATION DE LA CANNE À SUCRE

Par

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MOTS-CLÉS: Modélisation, APSIM, Facteurs Culturaux, Internet.

Resume

L'ADOPTION des services d'aide à la décision (DSS) basés sur des modèles de croissance a été faible et pourtant le concept de transférer une quantité croissante de connaissance scientifique par l'intermédiaire des DSS reste attrayant. Cette étude explore l'utilisation de l'Internet et de la recherche action participative (PAR) pour développer une gestion de l'irrigation, appelée '*WaterSense'*, pour les planteurs irriguant la canne à sucre en Australie. '*WaterSense'* combine deux précédents DSS basés sur le Web, conçus pour programmer l'irrigation lorsque la ressource en eau est soit limitante, soit abondante. Dans les deux cas, un nombre restreint de planteurs et de personnel d'encadrement a été impliqué pour concevoir et conduire les essais au champ destinés à tester les concepts qui furent par la suite inclus dans le DSS. Une procédure d'optimisation ('*Caneoptimiser*'), basée sur le modèle 'APSIM-Canne à sucre' a été développée pour appliquer des irrigations limitées quand le besoin était élevé. Cependant, l'optimisation trop lente pour fonctionner sur un serveur Web. Les planteurs ayant de l'eau en abondance ont réclamé le développement d'une technique de bilan hydrique simple (appelée 'WaterBalance') pour programmer l'irrigation par Internet. Les planteurs pourvus d'une irrigation limitée ont voulu le service offert par '*Caneoptimser'* avec la vitesse et le format de '*WaterBalance'*. Un nouveau service appelé '*WaterSense'* a été développé en utilisant les algorithmes de croissance du couvert et de dynamique de l'eau du sol issus de '*Caneoptimser'* et les algorithmes de calcul de l'evapotranspiration de référence et des facteurs culturaux issus de '*WaterBalance'*. L'adoption par les planteurs familiers de la recherche fut immédiate. Tout indique que l'utilisation combinée d'Internet, du PAR, et simultanément de la recherche et des démonstrations, ouvrira la voie à l'adoption des résultats de recherches dans la gestion de l'irrigation et probablement à d'autres aspects de la culture de la canne à sucre. Cependant, l'adoption généralisée des DSS ne peut pas dépendre de la participation de l'intensité exigée pour leur développement. Les processus d'adoption, au delà de l'étude de cas, nécessitent davantage de recherche.

UN SISTEMA BASADO EN LA WEB PARA PROGRAMACIÓN DE RIEGOS EN CAÑA DE AZÚCAR

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PALABRAS CLAVE: Modelaje, APSIM, Factores de Cultivo, Internet.

Resumen

LA ADOPCIÓN de los servicios de apoyo a decisiones (DSS por sus siglas en inglés) basados en modelos de crecimiento de cultivos ha sido modesta y ahora el concepto de transferir e incrementar el embalaje del conocimiento científico por medio del DSS permanece atractivo. Este estudio explora el uso del Internet y la acción de investigación participativa (PAR) para desarrollar un servicio de administración de riegos llamado *WaterSense* para los responsables de riego en caña de azúcar en Australia. *WaterSense* combina dos previos DSSs basados en la web, uno para usarse con agua limitada y otro para programar agua abundante. En ambos casos, se involucró un pequeño número de entusiastas productores y personal de extensión en el diseño y manejo de los experimentos de campo para probar conceptos que posteriormente serían incluidos en los DSS. Un procedimiento de optimización (‘*Caneoptimiser*’), basado en el modelo APSIM-Caña de Azúcar fue desarrollado para aplicar riego limitado cuando más se necesita. Sin embargo, la optimización tomó mucho tiempo para funcionar como un servicio en la web. Los productores con abundante agua aceleraron el desarrollo de una sencilla técnica de balance hídrico (llamada ‘*WaterBalance*’) para programar riegos por medio del Internet. Los productores con riegos limitados querían los servicios ofrecidos por *Caneoptimser* con la velocidad y formato de *WaterBalance*. Se desarrolló un nuevo servicio llamado *WaterSense* usando algoritmos para el desarrollo del follaje y la hidrología del agua del suelo del *Caneoptimser* y algoritmos para la evapotranspiración de referencia y factores de cultivo del *WaterBalance.* La adopción por parte de aquellos que están familiarizados con la investigación básica ha sido inmediata. Hay indicios de que el uso combinado del Internet, PAR, investigación relacionada y pruebas demostrativas abrirán el camino a la adopción de los hallazgos de investigación en el manejo del riego y probablemente otros aspectos en el cultivo de la caña de azúcar. Sin embargo, la adopción generalizada del DSS no puede depender de la participación con la intensidad requerida para su desarrollo. Los procesos de adopción más allá del caso de estudio requieren más investigación.