

Surface irrigation for energy and water use efficiency

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Summary

Work by two different groups within the former CRCIF has shown: (i) the energy costs of the various irrigation application systems including the 'efficient' pressurised systems, and (ii) the irrigation efficiency gains possible with improved surface irrigation. Combining the data from these two sources provides a compelling case for considering surface irrigation with real-time optimisation and control as the ultimate irrigation method for both energy and water use efficiency.

Introduction

Worldwide as well as in Australia, irrigated agriculture is the largest water user, and there is pressure on irrigators to improve water use efficiency as other sectors compete for water. One way commonly suggested for improving water use efficiency is to replace surface irrigation systems, with pressurised centre pivot and drip systems, which are assumed more efficient.

Irrigation is a primary consumer of energy on farms particularly when pumping is required, so any changes to the irrigation method used can be expected to change on-farm energy consumption. The direct energy inputs are primarily used to operate farm machinery and pumps, while indirect energy inputs refer to energy that is used to produce equipment and other goods and services that are used on-farm. Where groundwater is used, there is always more energy required for pumping. The energy required for pumping depends on the crop water requirement, total head, flow rate and system efficiency.

Surface Irrigation Efficiency

Previous research in sugar industry (Raine & Bakker, 1996) found application efficiencies for individual irrigations under farmer management averaged less than 50% and ranged from 14 to 90%. When irrigations were optimised to simulate real-time control (Raine *et al.*, 1997), the average application efficiency increased significantly from 41% to 93%.

Smith *et al.* (2005) reported a similar situation in the cotton industry. Application efficiencies from 79 furrow irrigations under farmer management had a mean of 47% and spanned the same range as in the sugar industry. Simulation of the events showed that the simple strategy of increasing flow rate and reducing time could increase the average efficiency to above 70%. Optimisation of the individual events gave efficiencies between 82 and 100% for all but a small number on very light soils. Following this study, Khatri and Smith (2007) established the feasibility of the real time optimisation and control of furrow irrigation.

More recently evaluations of bay irrigations in the GMID (Smith *et al.*, 2009, Gillies *et al.*, 2010) have showed improvements in application efficiency of about 20% to values in between 80 and 95% are possible across much of the region through the use of higher flow rates and real-time control.

Energy Usage

Energy consumption in irrigated agriculture results primarily from pumping requirements as illustrated in a recent case study in Australia by Jackson *et al.* (2010) who considered the

energy use for irrigation in two areas, the first supplied with surface water by gravity, and the second by groundwater. The water use and energy consumption by the current (inefficient) surface irrigation systems were compared with the reduced water use but greatly increased energy consumption that would occur if the surface systems were converted to centre pivot and drip irrigation. However they did not quantify the water or energy savings that would accrue from optimised surface irrigation.

It was shown earlier in this paper that irrigation application efficiencies of 85% are possible with optimised surface irrigation. This is used along with the energy consumption data from Jackson *et al.* (2010) to demonstrate the energy consumption benefits of optimised surface irrigation for a hypothetical annual grain crop in southern Australia (Table 1). The water source is a surface gravity supply and the energy used includes that for the cultural operations of land preparation, sowing, fertiliser, herbicides and harvesting. The increased energy consumptions for the centre pivot and drip systems are a direct result of the pumping required to give the desired operating pressures.

It is evident that with real-time optimisation and control of current surface irrigation, any water savings will be achieved without increase in energy consumption, making it both water and energy efficient. The table further reflects that when current surface irrigation was converted to centre pivot and drip irrigation there were further small water savings but this came with highly significant increases in energy consumption.

For the same crop irrigated from a groundwater source the additional energy consumed would be a direct function of the volume of water pumped and the depth to groundwater. In some circumstances this may cause the current 'inefficient' surface irrigation to be more energy expensive than the pressurised systems (Jackson *et al.* 2010). However, even in that event, real-time optimised surface irrigation will deliver the lowest energy consumption.

Table 1 Illustration of energy consumption for irrigation of a hypothetical grain crop from a surface water source

System	Water applied (ML/ha)	Water savings (ML/ha)	Energy use (MJ/ha)	Increase in energy use (MJ/ha)
Current surface irrigation (E_a 55%)	7.3		9700	
Real-time optimised surface irrigation (E_a 85%)	4.7	2.6	9700	0
Centre-pivot irrigation (E_a 90%)	4.4	2.9	17000	7300
Drip irrigation (E_a 95%)	4.2	3.1	16000	6300

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