SELECTION OF FLOW RATE AND IRRIGATION DURATION FOR HIGH PERFORMANCE BAY IRRIGATION

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INTRODUCTION

The maximum performance (efficiency) of surface irrigation is determined largely by the soil infiltration characteristic and the flow rate onto the field. Previous studies by the CRC for Irrigation Futures (Smith *et al.,* 2009 and Gillies *et al.,* 2010) have suggested that higher flow rates than those traditionally used can lead to increases of about 20% in the application efficiency of bay irrigation across the dairy regions of southern Australia. However, substantially reduced irrigation durations are required to realise these efficiency gains. Consequently greater accuracy and precision is required in the selection and management of these shorter durations.

METHODOLOGY

In this paper, infiltration data for the main soil types across the region are collated from a variety of sources and a range of representative case study soils selected. For each of the case study soils, irrigations were simulated using the SISCO hydraulic simulation model for a range of flow rates and lengths. Each irrigation application was optimised to determine the duration of inflow or time to cut-off (*Tco)* that would give maximum application efficiency (*Ea*). Run-off from the end of the bay was set to 5% to ensure that the irrigation always reached the downstream end of the bay. The other usual performance parameters of requirement efficiency (*Er*) and uniformity were also calculated for each irrigation, along with an estimate of the deep percolation loss.

SIMULATION RESULTS

In most cases (e.g. Figure 1) the application efficiencies (*Ea*) show a rising trend with increasing flow rate until reaching a plateau at some particular flow rate. The magnitude of this flow rate is a function of the soil type, bay length and deficit, being higher for the more permeable soils, longer bays and higher deficits. The exception was the cracking soil type with a short bay length and low deficit, where the application efficiency was essentially constant at all flow rates. At or just before the point of maximum *Ea*, the requirement efficiency (*Er*) was generally adequate (> 95%) thus defining the preferred flow rate. At this flow rate the irrigation durations (*Tco*) were typically about 2 to 3 hours except for the very long bays and high deficits.

The simulation data also show that application efficiencies in excess of 90% are possible on many soils in the region. The exceptions are for longer bays on the more permeable soils where maximum application efficiencies reduce to less than 80%. These are maximum possible application efficiencies and assume perfect selection and control of *Tco*. Few farmers would be achieving maximum efficiencies at their current flow rates and without assistance would certainly not achieve them if they adopted higher flow rates.

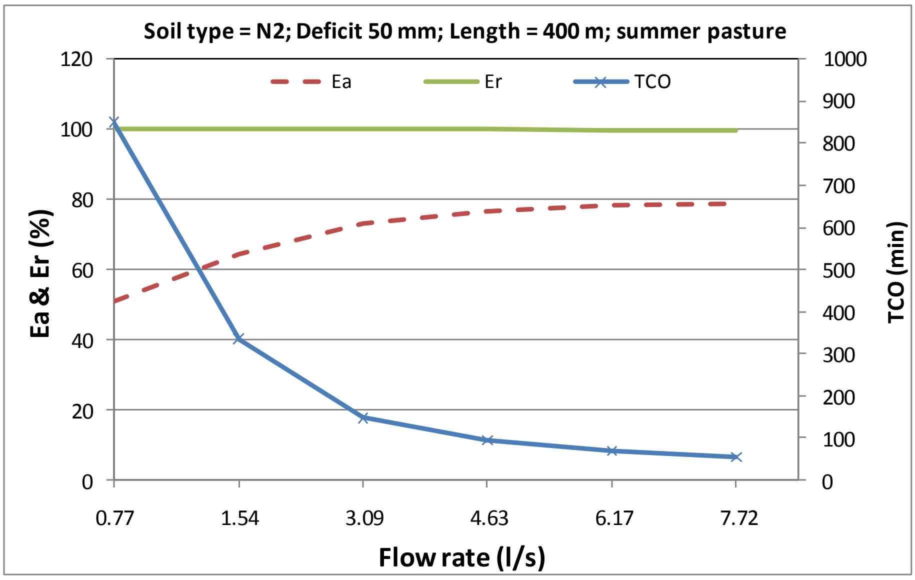

Figure 1 Example results for a moderately permeable non-cracking soil

GUIDELINES

The purpose of the study is to provide a guide to irrigators moving to employ higher flow rates. The simulations suggest preferred flow rates for cracking soils of 6 ML/d/ha for irrigation of pasture with soil moisture deficits up to about 50 mm. For pasture on non-cracking soils the recommended flow rates depend on the soil permeability with 6, 10 and 14 ML/d/ha recommended for lowly, moderately and highly permeable soils, respectively. For a 400 m long 50 m wide bay, these flow rates correspond to unit rates of 0.24, 0.4, and 0.56 ML/d/m width or 2.8, 4.6 and 6.7 L/s/m width. These rates should be increased by 2 ML/d/ha for irrigation of deep rooted fodder crops with deficits in the order 80 to 100 mm. The proposed rates are about twice the magnitude of previous guidelines of Lavis *et al.* (2006). In some instances the recommended flow rates might exceed the supply rate available, in which case growers will have to balance the potential small loss of application efficiency with the cost of reducing bay widths to increase the effective flow rate.

The challenge in selecting values for irrigation duration or *Tco* appropriate to any flow rate is to recognise that the variations in infiltration within a soil type and due to changes in antecedent moisture content can be as great as the variations across soil types. Hence guidelines must be adaptive to the conditions prevailing at the time of any irrigation. A method based on observation of advance time is proposed and will take the form of a series of charts similar to those in Figures 2 and 3.

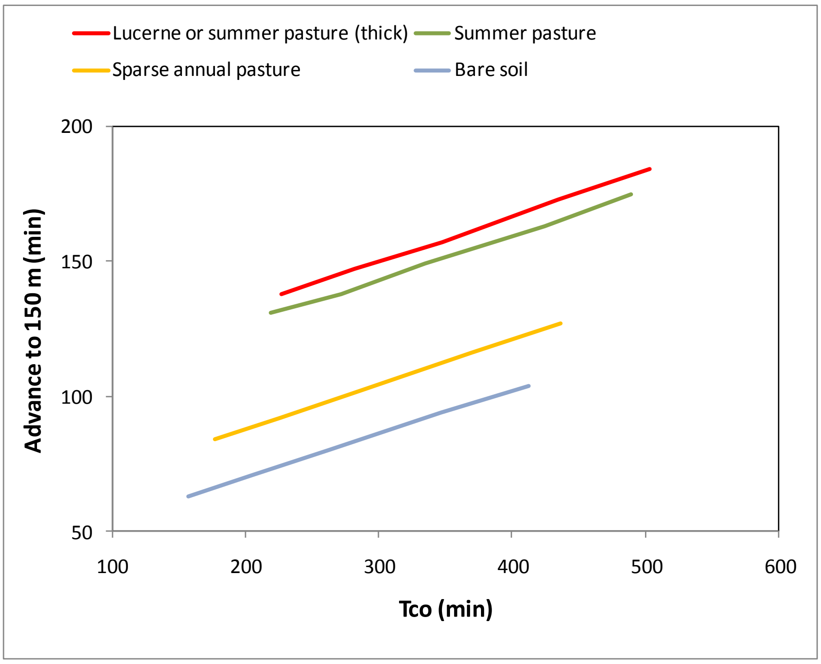

Figure 2 Example of guidelines for selection of time to cut-off (*Tco*) for a non-cracking soil type, bay length 400 m and flow rate 1.54 L/s/m

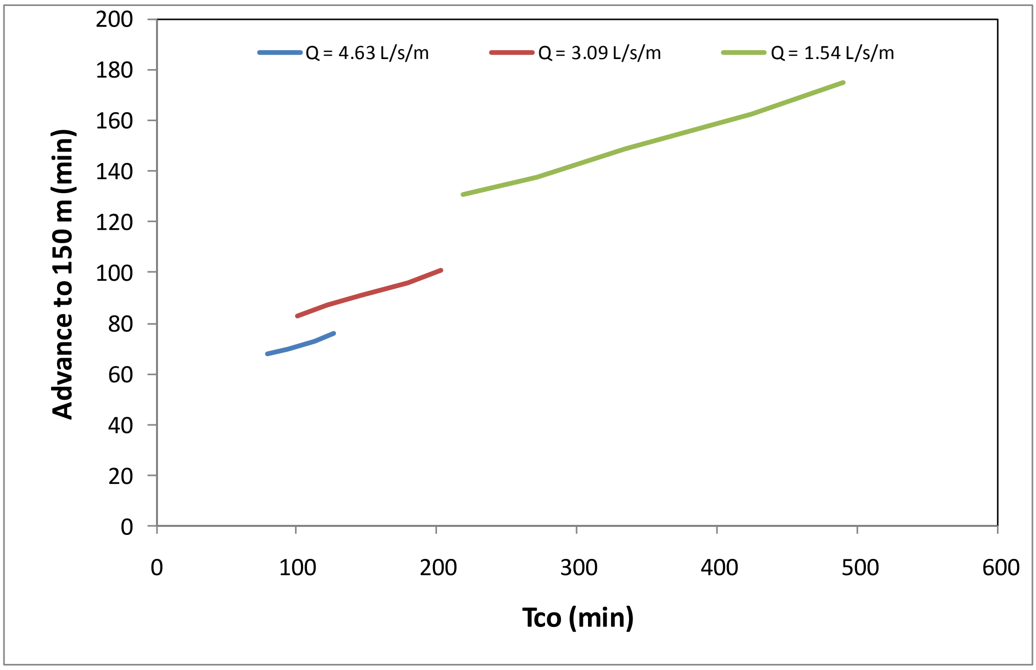

Figure 3 Advance vs optimum *Tco* for summer pasture in a 400 m long bay on a cracking soil at various inflow rates

For a cracking soil, if the deficit is known, a simple volume balance approach will yield similar times to cut-off without recourse to the charts. For example, for a 400 m long bay, flow rate of 3.09 L/s/m width, and deficit of 50 mm, a volume of 20 m^3 of water needs to be applied. This is increased by 5% to 24 m^3 to ensure the advance reaches the end of the field. At the specified flow rate this means a *Tco* of 130 min.

CONCLUSIONS

The simulation work described above indicates that it is feasible to provide guidelines for the management of bay irrigation and in particular for higher flow rates. Two areas need further work. The first is to explore various alternatives for presentation and delivery of the guidelines which will enable them to cover the infinite combinations of bay lengths, flow rates, and crop conditions that are possible, while remaining comprehensible to and useable by farmers. The second task is to trial the guidelines in the field and in the case of the non-cracking soils to confirm the assumptions contained in the guidelines in respect of the effect of varying the soil moisture deficit.

ACKNOWLEDGEMENTS

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