

SHORT NON-REFEREED PAPER

A SIMPLE DEVICE TO IMPROVE FURROW IRRIGATION EFFICIENCIES

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Abstract

Many of the 'textbook' evaluation and modelling techniques used to optimise the performance of furrow irrigation systems are difficult to apply on a wide scale and are not well suited to routine application on-farms or estates. As a result, the performance of furrow irrigation systems in practice is often poor. Considering that large proportions of the sugarcane grown in southern Africa are irrigated using furrows, an uncomplicated and practical procedure to monitor and improve the performance of furrow irrigation systems would be valuable. In this paper, a simple, low cost device named a 'Greller' is described together with an example of how it can be used in practice to improve the performance of furrow irrigation systems. Personnel on farms and estates have been trained to use the Greller and its use has shown that the non-beneficial and detrimental components of the water balance are often excessive. The Greller is packaged with 'User Guidelines' which, when applied, can result in substantial reductions in water losses. Water savings have often been in excess of 20%. In a relatively few fields the use of the Greller has highlighted substantial under-irrigation which can also be corrected. The Greller is an appropriate and practical technology for many sugarcane farmers and estates in southern Africa, due to the fact that it is low-cost, effective and simple to use.

Keywords: furrow irrigation, efficiency, water balance, evaluation, performance, sugarcane

Introduction

Furrow irrigation may appear to be simple in concept; however, optimising the performance of furrow irrigation systems can be challenging. A number of evaluation procedures and systems have been reported in the literature on furrow irrigation. Examples include the FAO Irrigation and Drainage Paper No. 45 (Walker, 1989), the Manual for the Evaluation of Irrigation Systems developed for South Africa (Koegelenberg and Breedt, 2003) and the IrriMATE™ system developed in Australia (Raine *et al.*, 2005).

All these evaluation and optimisation approaches are time consuming and they require a certain degree of expertise and understanding to be applied effectively. They can be very useful for optimising the performance of single furrows. However, there are thousands of furrows and hundreds of furrow irrigated fields in many of the sugarcane growing regions of southern Africa. Therefore, a less complicated, more practical and relatively inexpensive procedure to monitor and improve the performance of furrow irrigation systems would be valuable. In this paper, a simple, low cost device named a 'Greller' is described together with

an example of how it can be used in practice to facilitate substantial improvements in the performance of furrow irrigation systems.

Methodology

The amount of water applied to a number of representative furrows per field is measured and used to determine the average amount of water applied per furrow and the variation between furrows. Ideally, at least 25 furrows per field should be assessed.

Measuring the depth of water applied to furrows

The authors developed the simple device shown in Figure 1 to measure siphon flows. The Greller enables the measurement of furrow in-flows to be integrated with standard irrigation operator responsibilities, thereby facilitating widespread and relatively easy collection of appropriate furrow irrigation performance data (Griffiths, 2007).

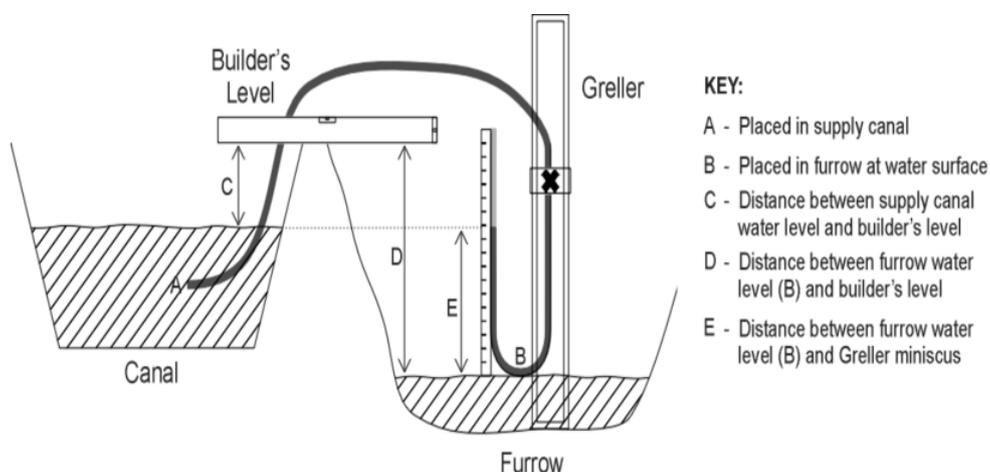


Figure 1. The Greller device used to measure the head driving flow in a siphon (after Griffiths, 2007).

As shown in Figure 1, clear tubing filled with water is placed in the supply canal (the feeder) at point A. Point B, the ‘zero’ reading on ruler, is placed in the furrow and positioned so that it just touches the water in the furrow if the siphon outlet is submerged. If the siphon outlet is not submerged, point B is aligned level with the centre of the siphon outlet. The difference in water level between the feeder and the furrow water levels or centre of the siphon outlet is read from the ruler attached alongside the clear tubing (distance ‘E’ in Figure 1). Grellers are not expensive and are simple to make. Knowing the hydraulic head driving flow, the internal diameter of the siphon and the coefficient of discharge for a particular siphon type, the flow-rate can be determined using Equation 1. The coefficient of discharge, C_d , for a particular siphon is determined through calibration.

$$Q = C_d A_s (19.62H)^{0.5} \tag{Eq 1}$$

where

$Q(m^3/s)$ = flow-rate

$A_s (m^2)$ = siphon area = $\pi d^2/4$

$d (m)$ = internal diameter of siphon

C_d = coefficient of discharge

$H(m)$ = head = $(D-C) = E$ (for a submerged siphon outlet).

Once the flow-rate into furrows has been determined, the average depth of water applied is easily calculated by converting the flow-rate to a volume, i.e. multiplying the flow-rate by the time during which water flows into the furrow, and then dividing the volume by the representative furrow area, i.e. the furrow length multiplied by the furrow spacing.

Results

The following example illustrates how the Greller was used to assess and improve the performance of furrow irrigation on a field which had just had sub-surface drainage installed. First the Greller was used to determine the average depth of application and then some adjustments were assessed in an effort to reduce losses.

Case study example

After taking a few simple measurements at the field and asking questions of the irrigation supervisor, it was found that the:

- Total Available Water (TAM) estimate was 70 mm
- planned deficit at which water was being applied was taken to be 50% of TAM, i.e. 35 mm
- average siphon flow measured with the Greller was = 3 L/s
- one siphon was being used per furrow
- average siphon time per furrow was 55 minutes, therefore, the average volume applied per furrow was $(3 \times 55 \times 60)/1000 = 9.9 \text{ m}^3$ (flow-rate x time)
- furrow length was 136 m and the row spacing was 1.5 m, therefore, the area per furrow was $136 \times 1.5 = 204 \text{ m}^2$ (row spacing x field length)
- average depth of water applied per furrow was, therefore, $9.9/204 = 0.0485 \text{ m}$ or 48.5 mm (volume/area).

At every irrigation application this field was typically receiving an extra $48.5 - 35 = 13.5 \text{ mm}$ of water, i.e. an excess of 39% on average, relative to the planned deficit or target application depth.

What could be done to improve?

Applying such excessive amounts of water each time the field was irrigated would be one of the main causes of the high water table and the need for extensive drainage, and would result in other problems such as nutrient leaching. Previous work using a Greller has shown that such a scenario, where excessive amounts of water are applied with furrow irrigation, is actually widespread (Lecler, 2004); however, making a few simple adjustments as described below can lead to major improvements. Also shown is that some adjustments which are often proposed may actually lead to increased losses unless they are properly assessed using a device such as the Greller.

- *Increase the number of siphons to two per furrow – often thought to lead to reduced application depths*
As expected, the advance front reached the end of the furrow more quickly and the irrigation time reduced to 39 minutes; however, with the flow per furrow increasing to 6 L/s with the two siphons, this equated to a depth of 69 mm of water applied per irrigation and would result in even greater losses.

- *Adjust the planned deficit*
Excavations for the drains indicated that the soil depth was >0.8 m. Thus, the TAM was likely to be closer to 80 mm (using a rule of thumb of ± 100 mm of available water per metre depth of soil). Thus, the deficit at which irrigation applications are planned could be increased to, say, 42 mm, without many detrimental effects. Even where soils are not that deep, increasing the planned deficit by small amounts is unlikely to impact sucrose yields and may even be of benefit (Inman-Bamber and Smith, 2005; Robertson *et al.*, 1999).
- *Reduce the siphon times*
The siphon times could be reduced to, say, 50 minutes without a major impact on depth of water applied towards the end of the furrow, i.e. reduce siphon times by 5 minutes.

Impact of changes

Volume applied = $50 \times 3 \times 60 = 9 \text{ m}^3$

Average depth of water applied = $9/204 = 0.0441 \text{ m}$ or 44 mm

Excess water applied relative to calculated deficit = $44 - 42 = 2 \text{ mm}$ or 5%.

Conclusion

Use of the Greller could result in widespread improvements in the performance of furrow irrigation systems due to the fact that it is low-cost, effective and simple to use.

In the example reported, use of the Greller facilitated waste water to be reduced from 39% to 5%. Had the adjustments facilitated by the Greller been done previously in the case study example, it is likely that yields on the field would have been better, substantial water savings would have been achieved, nutrients would have been used more effectively and the water table was likely to have been lower and less problematic.

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