

IMPROVING THE EFFICIENCY AND PROFITABILITY OF FURROW IRRIGATION FOR SUGARCANE PRODUCTION

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ABSTRACT

Trials were conducted on commercial sugarcane properties to investigate the efficiency and financial benefits associated with alternative furrow irrigation management practices. Modifications to the furrow shape to produce a narrow “v” shape with surface compaction were shown to reduce water use throughout the season by 45%. This represented a saving of \$218/ha/yr to the grower and a potential saving of \$1.74M annually to the Burdekin sugar industry. Where furrow lengths of 300 m were used instead of 600 m, the volume of irrigation water applied was reduced by 42%. These shorter furrows were found to produce a net return of either \$132 or \$210/ha/yr after the capital and production costs were assessed, depending on the nature of the water delivery system installed.

INTRODUCTION

Previous research investigating the efficiency of furrow irrigation practices has shown that the efficiency of current practices in the Australian sugar industry are highly variable. Raine (1995) found that seasonal water application efficiencies (defined as the proportion of the applied water available for use by the crop) for furrow irrigation of sugarcane ranged between 31 and 62% on farms where tailwater was not recycled, while efficiencies for individual irrigations ranged between 14 and 90%. Low water application efficiencies were generally found in areas of highly permeable soils with the majority of water loss attributed to deep drainage. In these areas, significant improvements in the irrigation efficiency are possible using a variety of management practices including shorter furrow lengths and changes in furrow shape to introduce surface compaction (Raine 1995). However, growers are generally reluctant to adopt these alternative irrigation strategies unless the operational and financial benefits are demonstrated under commercial conditions.

This paper reports the results from trials conducted on commercial cane farms to improve the efficiency of furrow irrigation by encouraging the adoption of shorter furrow lengths and narrow furrow shapes with surface compaction. It also presents the results of preliminary cost-benefit analyses conducted to identify the on-farm commercial implications of these strategies.

MATERIALS AND METHODS

All trials and analyses were conducted on commercial, furrow-irrigated farms in the Burdekin River Delta area during 1994-95 using typical management practices and operational costs. Each site was located on highly permeable alluvial soils that are typical of 20% (c.8000 ha) of the Delta area.

Irrigation efficiency

The effect of furrow shape and surface compaction on the application efficiency of the first irrigation after hill-up was initially investigated at sites in the Colevale and Maidavale areas. Paired trial sites were established at each location with treatments consisting of a normal “u” shape furrow produced without surface compaction using hill-up boards, and a modified “v” shape furrow with surface compaction produced by tilting the hill-up boards forward approximately 10-15%. The irrigation performance of eight individual furrows in each treatment were measured. To investigate the effect of this treatment on the rate of irrigation water advance along the furrow and application efficiency for the whole season, all irrigations conducted between hill-up and harvesting were monitored at a third site located in Home Hill. The equipment and methodologies employed to monitor irrigation performance at each site were the same as used by Raine (1995). Cane production at the Home Hill site was also calculated from the mill bin weights at harvest.

The effect of furrow length on irrigation efficiency was determined using the surface irrigation model SIRMOD (Walker 1993). Model input parameters were derived using data obtained from actual irrigations conducted in the Burdekin Delta area. Furrow lengths of 300 m and 600 m were chosen to evaluate the water application efficiency and conduct a cost-benefit analysis because they represented typical alternatives confronting growers in the area.

Cost-benefit analyses

Cost-benefit analyses were conducted to evaluate each of the alternative irrigation strategies outlined above. However, only the costs and benefits that were directly attributable to the change in irrigation management were used for these analyses. The prices and costs used were typical of those encountered in the Burdekin during 1995. In this area, the growers pay for water based on a flat levy on the tonnage of cane produced. Hence, the actual cost of the water (expressed per ML) is a function of (a) the levy, (b) the amount of cane produced (irrespective of actual water usage) and (c) the fixed pumping and maintenance costs associated with applying the water. In general, the actual cost of the water is between \$3 and 3.50/t cane. Thus, assuming an average water cost for the Delta growers of \$3.25/t cane (including electricity/fuel, pump maintenance, depreciation and levies), an average production of 124 t cane/ha and a water use of 25 ML/year, the average cost of the water in this area is \$16.12/ML. For these analyses, the gross return for cane production to the grower was assumed to be \$35/t cane.

For the comparison between the furrow shape treatments, only the water cost was included as there was typically no additional time, equipment or resource implications associated with implementing this treatment. However, for the analysis of change in furrow length, the costs associated with the purchase and installation of additional water supply works were included along with the production losses associated with the additional headland area. This analysis was conducted for a 12 ha block with 600 m furrows which could be split into two, 6 ha blocks with 300 m furrows. Two water delivery installation options were considered, a permanent underground pipe system with an assumed working life of 15 years, and a temporary above ground layflat flume system with an assumed working life of 5 years. All capital expenses are based on the retail cost of purchasing and installing the required works. Based on field observations for these soils, production losses associated with inadequate watering of the long furrows were also included in the analysis. It was assumed that there was no decrease in production and commercial cane sugar (CCS) for furrows up to 500 m in length. However, production was assumed to decrease linearly with furrow length after 500 m by 0.03 kg cane/m and CCS by 0.03 units/m. No allowance has been made in the analysis for any additional labour, tillage or harvesting associated with shorter furrows.

RESULTS

Furrow shape and surface compaction

The effect of furrow shape on the volumes of water applied in the first post hill-up irrigation at the Colevale and Maidavale sites are shown in Table 1. For both soils, the modified “v” shape furrow required the application of less than 40% of the volume applied to the normal “u” shaped furrows. This effect appeared to be similar for subsequent irrigations throughout the season as the average volume of water applied for each of 15 irrigations monitored at the Home Hill site were 1.99 ML/ha and 1.09 ML/ha for the normal and modified furrow shapes, respectively. No difference in production was observed at this site with the “u” and “v” shaped furrows producing cane yields of 161 and 159 t/ha, respectively. As there were no additional capital or operating requirements to produce the “v” shaped furrows, and there was no difference in production, the only direct financial effect is associated with the reduced water usage. Based on water use figures at the Home Hill site, using “v” rather than “u” shaped furrows produced a financial benefit of \$218/ha/yr. This represented a saving of \$10,900 per annum for a 50 ha farm or \$1.74M per annum for the local industry assuming that similar benefits could be obtained on one-fifth (c. 8000 ha) of the area farmed in the Burdekin Delta.

A substantial time saving (up to 40%) was also obtained by changing to the “v” shaped furrows from the “u” shaped furrows. At the Home Hill site, the average period of irrigation for a 470 m furrow was reduced from 12 to 8 h per irrigation set. This enabled the farm to be irrigated quicker and produced a number of other benefits including a reduced requirement for additional and/or larger pumping and supply systems, and the introduction of irrigation scheduling which was previously limited by the time required to irrigate.

Furrow length

Decreasing the furrow length from 600 m to 300 m would decrease the volume of irrigation water required to be applied from 1.78 to 1.03 ML/ha/irrigation. Table 2 shows the production costs and benefits associated with changing from the 600 m to 300 m furrow length. The costs associated with the two options for redistributing the water are also indicated. For both options, a positive economic return was found with an annual benefit of \$210/ha and \$132/ha for the temporary and permanent installations, respectively. This indicates that the financial return for implementing this change over an average 50 ha farm would be either \$6600 or \$10,500 per year depending on the water delivery system installed.

Note that in this example, almost half of the projected benefit is due to an increase in production associated with higher water distribution uniformities on the shorter furrows. Where there is no production benefit because the initial furrow length achieves high uniformities, the benefit associated with adopting shorter furrows is limited to the water saving. However, these water savings also decrease rapidly as the initial furrow length decreases, with the direct financial benefit greatly influenced by the cost of the water. It should also be noted that the actual return in each case may be smaller than that indicated as there is no allowance in these calculations for the additional labour, tillage or harvesting costs which may occur with shorter furrows.

CONCLUSIONS

Substantial improvements in the efficiency of furrow irrigation for sugar cane production can be obtained on high infiltration soils in the Burdekin Delta through the adoption of alternative irrigation management strategies. While the direct financial benefits associated with the introduction of changes in furrow shape and furrow length may be substantial, further work is required to fully cost these irrigation strategies under a range of farm conditions and to include the effects on farm labour, tillage and harvesting requirements.

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REFERENCES

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Table 1. The effect of changing furrow shape on water usage in the post hill-up irrigation at the Colevale and Maidavale sites.

Furrow shape	Irrigation water applied (ML/ha)			
	Colevale		Maidavale	
	Average	Range	Average	Range
Normal “u”	8.3	8.1-8.4	7.3	4.6-12.9
Modified “v”	2.9	2.8-3.4	2.9	2.8-6.5

Table 2. The annual costs and benefits associated with converting a 12 ha sugar cane block with 600 m furrow lengths into two, 6 ha blocks with 300 m furrow lengths.

Item	Cost (\$)
<i>Benefits</i>	
Water saving	2080
Production gains	2052
Total	4132
<i>Costs (Option 1 - Permanent installation)</i>	
Pipeline (\$20250 depreciated at 6.7% p.a.)	1350
Risers (\$3000 depreciated at 6.7% p.a.)	200
Fluming and cups (\$610 depreciated at 20% p.a.)	122
Headland production (0.2 ha)	868
Total	2540
<i>Costs (Option 2 - Temporary installation)</i>	
Supply fluming (\$2100 depreciated at 20% p.a.)	420
Fittings (\$1000 depreciated at 20% p.a.)	200
Fluming and cups (\$610 depreciated at 20% p.a.)	122
Headland production (0.2 ha)	868
Total	1610