BUREAU OF SUGAR EXPERIMENT STATIONS

QUEENSLAND, AUSTRALIA

FINAL REPORT
LWRRDC PROJECT BSE2
INCREASING IRRIGATION EFFICIENCIES IN THE AUSTRALIAN SUGAR INDUSTRY

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SUMMARY

The LWRRDC funded project, BSE2 (Increasing Irrigation Efficiencies in the Australian Sugar Industry) has increased Water Use Efficiencies (tonnes of cane produced per ML of total water applied, including irrigation and effective rainfall) in the lower Burdekin.

Over 20 furrow irrigation sites on the Burdekin Delta were monitored by sugarcane growers for water use through the 1995/96 and 1996/97 seasons. Irrigation efficiencies varied from less than 20% to nearly 70%.

Demonstration trials compared 'U' and 'V' furrow shapes and conventional versus reduced tillage. Deep drainage losses on highly permeable soils were halved by the use of either 'V' shaped furrows or reduced tillage. A combination of these treatments on one case reduced water usage by up to 70% without having any effect on final yield. The water saving reduces the pressure on the water resource, and lessens the potential for off-site losses of nutrients and pesticides though deep drainage.

Around 500 minipans have been distributed to growers in the Burdekin. Productivity data collected from the last two seasons has shown that growers using minipans increased sugar yield by over three-quarters of a tonne of sugar per ha without using any extra water. This significant increase in yield is worth over $15,000 to a grower with 70 ha.

A cost:benefit analysis showed potential savings of over 100,000 ML/year in the Burdekin Delta if growers adopt 'V' shape furrows and reduced tillage on freely draining soils. This water saving plus the increase in productivity from the adoption of minipans is worth $15.7 million to the Burdekin sugar industry.

Much of the success of BSE2 project can be attributed to grower involvement from the outset of the project. This participatory method of extension will certainly become increasingly popular in the future.

1.0 INTRODUCTION

Approximately 25% of Australian caneland is furrow irrigated. The expanding regions of the Burdekin, Mareeba and Proserpine will increase this proportion. Research conducted by BSES (Bureau of Sugar Experiment Stations) has shown that water use efficiencies of 12-15 tonnes/cane/ML were achievable in field trials, although commercial furrow irrigation practices were only achieving between 4 and 8 tonnes/cane/ML. There was a real need to improve these efficiencies, by reducing irrigation losses and improving irrigation scheduling on furrow irrigation. It was thought that this would increase productivity and reduce the use of irrigation water, leading to reduced groundwater accession and less tailwater discharge.

In 1995 the Land and Water Resources Research and Development Corporation funded the two-year project 'Increasing Irrigation Efficiencies in the Australian Sugar Industry'. The main aim of the project was to develop a model for the adoption of improved irrigation practices using grower focus groups and participatory interaction. Since the Burdekin district of north Queensland is the largest single area of sugarcane that is furrow irrigated in Australia, the project was focussed on that district.

The specific objectives of the project were:

- Encourage irrigation scheduling and water use monitoring by all growers.
- Increase water use efficiency by 1 tonne cane/ML on 25% of furrow irrigated canefields.
- Reduce water use by 1 ML/ha/year on 25% of furrow irrigated canefields.
- Develop benchmarks and set standards for efficient water use by canegrowers.
- Develop a framework for improving grower adoption of irrigation technology that can be applied to technology transfer on other irrigated crops and areas.

2.0 METHODS

The project was conducted using a three-phase model incorporating grower feedback at each level. A significant component involved direct participation by growers working within cell groups. Growers within each group were requested to monitor water use on their own farms in the Burdekin Delta (an area of the Burdekin that has few on-farm water meters and water use is generally not recorded). Growers in the groups were also introduced to the BSES evaporation minipan. They were shown how to calibrate the minipans to crop growth to ensure accuracy on their own properties. It was important to ensure that the growers had ownership of the research they were conducting so that adoption of the findings would be immediate.

2.1 The General Awareness Phase

The general awareness phase started with the results of the previous furrow irrigation research trials being promoted through the Burdekin sugar industry. This was accomplished by the use of the local media, small on-farm field days and the annual BSES field day in the Burdekin.

In 1995 twelve grower groups were formed in both the Burdekin Delta and the Burdekin River Irrigation Area (BRIA). At the first meeting of the groups, results from the project 'Maximising the Efficiency of Furrow Irrigation Through Better Design and Management of Canefields' (BS90S, funded by the Sugar Research and Development Corporation, SRDC) were explained to growers as background information.

This phase of the project also included a survey of 40 growers from both the Burdekin Delta and BRIA to establish current irrigation practices and possible constraints to the adoption of improved irrigation practices.

2.2 The Participatory Phase

The participatory phase involved the installation of on-farm evaporation minipans to improve irrigation scheduling and in-field water meters to enable growers to collect water use data. The minipans were promoted at all focus group meetings throughout the Burdekin, whilst the water meters were mainly targeted at Burdekin Delta growers (because of the lack of water meters in this area). The cell groups were held approximately every six months and it was essential that extension officers from BSES organise and facilitate the meeting.

In the 1995/96 irrigation season, 13 growers recorded their water use on individual fields of plant cane. In the 1996/97 season, 8 growers recorded their water use on either plant or first ratoon crops.

In conjunction with the SRDC funded project 'Water Check', over 500 minipans were distributed to growers, with approximately half of them calibrated to crop growth rates.

The collection of the water use data provided accurate irrigation usage for the first time in the Burdekin Delta. As the sites were located on a range of soil types, the data were useful for benchmarking irrigation efficiencies and typical water usage for the Burdekin Delta. These data were presented at grower meetings in the participatory phase of the project. The data enabled us to discuss ways of improving irrigation efficiencies with the growers in the cell groups. A number of different options were presented to the growers on freely draining soils as possible ways of improving irrigation efficiencies.

These included:

- Changing to an alternative irrigation system
- Shortening furrow length
- Increasing furrow slope
- The increased use of lower EC water
- Reduce cultivations
- Change furrow shape from broad 'U' to narrow 'V'
- Surge irrigation
- Increase inflow rates
- Better attention to 'shut-off' times or recycling tailwater.

It was found that growers were very unwilling to adopt practices that would cost them substantial amounts of money. This was particularly the case with changing irrigation systems to either overhead systems or trickle. Shortening or increasing slope were also unpopular, as many of the growers had spent considerable amounts of money leveling and joining fields for ease of management. Only a small number of growers had access to lower EC water (open water) and these growers were already using this water as much as possible as they found that irrigation times could be reduced with its use. Growers on very freely draining soils were also generally using the maximum flow rate their systems would allow to get the water through to the end of the furrow. Surge irrigation was seen as being costly and difficult to use in practice, although previous trials have shown water savings of 20% on freely draining soils.

After discussion with all the cell groups, it was decided that the practices most likely to be adopted would be changing furrow shape from a broad uncompacted 'U' shape to a narrow compacted 'V', and the reduction in the number of cultivations, especially in plant crops.

Therefore in the second year of the project (1996-97) three on-farm trials were established to measure the effect of reducing cultivations and changing furrow shape on water use and yield.

2.3 The Evaluation Phase

The evaluation phase involved the comparison of technology adoption rates prior to and after the implementation of the project. This was completed by surveying 37 growers, half of whom were surveyed initially and the other half were new growers. This phase also included an economic evaluation of the financial benefits to the local industry and a cost:benefit analysis of the project.

3.0 RESULTS

3.1 Irrigation Water-Use Data

The data collected from the 13 irrigation monitoring sites in the 1995/96 season and the 8 monitoring sites in the 1996/97 season (Tables 1 and 2) show the wide variation of water usage in the Burdekin Delta. It also demonstrates that there is a wide range of irrigation efficiencies on all the main soil types of the Delta. This suggests that soil type has less bearing on irrigation efficiencies than some other factor. No pattern emerges with furrow slope or length or with the quality of water used. Therefore it is most likely that the variation in irrigation efficiencies is most likely due to different management practices.

Table 1. Irrigation application efficiencies of Delta plant cane (1995/96)

Soil type	*Average volume ML/ha/irrigation*	*RAW ML/ha*	*Deep drainage losses ML/ha/irrigation**	*Irrigation application Efficiency (%)*	*Drill Length (m)*	*Water EC (dS/m)*
Sandy loam	0.6	0.4	0.1	68%	335	0.22
Sandy clay loam	0.7	0.5	0.1	67%	630	1.22
Silty clay loam	0.8	0.5	0.2	66%	380	1.89
Clay loam	1.2	0.7	0.4	58%	370	0.35
Sandy loam	0.9	0.5	0.3	54%	650	0.49
Sand	0.7	0.3	0.3	46%	700	1.12
Sandy clay loam	1.7	0.5	1.1	29%	760	0.33/ 1.45
Clay loam	2.4	0.7	1.6	29%	390	0.35
Loam	2.3	0.6	1.6	27%	150	1.05
Sandy loam	2.1	0.5	1.5	24%	225	0.43
Sandy clay loam	1.9	0.5	1.4	24%	400	0.50
Clay loam	5.4	0.7	4.6	13%	830	1.71
Sandy loam	4.0	0.5	3.4	13%	150	0.49
Average	**1.89**		**1.26**	**40%**	**459**	

*assumes 0.1 ML/ha tail water losses
RAW refers to Readily Available Water

In the 1996/97 season, the average irrigation efficiency of plant crops was very similar to the 1995/96 season (Table 2 cf. Table 1). Table 2 also shows that irrigation efficiencies generally increase in first ratoon crops compared to plant crops. The reason for this is probably because of less cultivation in ratoon crops, and compaction/consolidation from both water and machinery reducing the deep drainage losses.

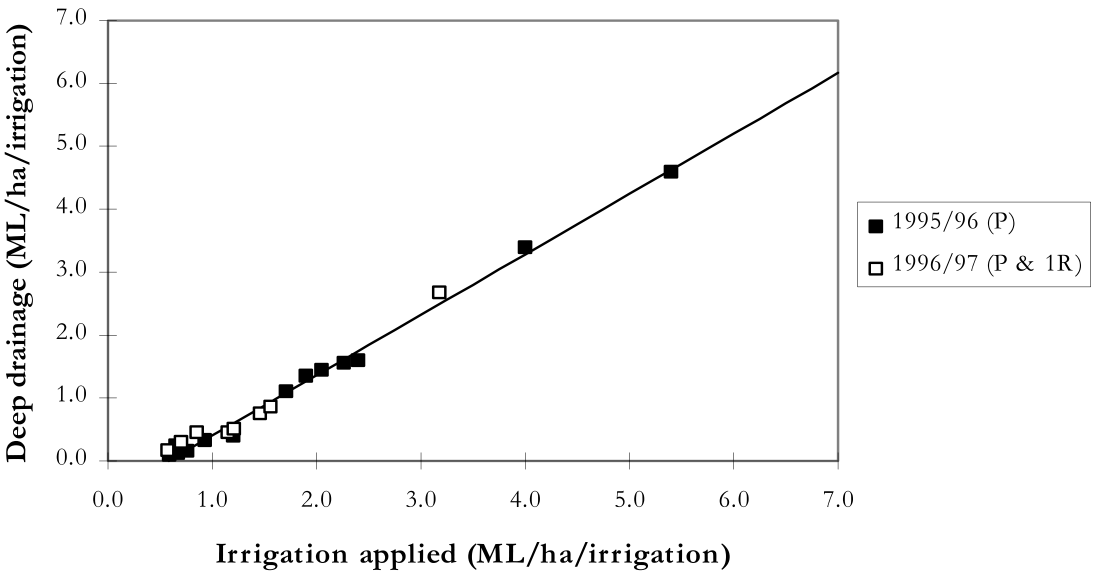
Table 2. Irrigation application efficiencies of Delta plant and first ratoon cane (1996/97)

Soil type	*Average volume ML/ha/irrigation*	*RAW ML/ha*	*Deep drainage losses ML/ha/irrigation**	*Irrigation application efficiency (%)*
Plant				
Clay loam	1.2	0.7	0.7	58%
Sandy loam	0.7	0.4	0.3	57%
Clay loam	1.6	0.7	0.9	44%
Sandy loam	3.2	0.4	2.8	13%
Average	**1.66**		**1.18**	**43%**
First ratoon				
Sandy loam	0.6	0.4	0.2	70%
Clay loam	1.2	0.7	0.5	61%
Clay loam	1.5	0.7	0.8	48%
Sandy loam	0.9	0.4	0.5	47%
Average	**1.05**		**0.50**	**57%**

*assumes 0.1 ML/ha tail water losses
RAW refers to Readily Available Water

The main irrigation loss from the monitoring sites in the Burdekin Delta was found to be from deep percolation past the root zone (Figure 1). Tailwater losses were generally very hard to measure, but were measured on several occasions in the Delta using in-furrow meters. Generally on the very freely draining soils, there was little or no tailwater. For this reason 0.1 ML/ha/irrigation tailwater, even though assumed in Figure 1, is thought to be an overestimate of the average tailwater loss in the Delta.

Figure 1. Deep drainage loss as a function of total water applied to alluvial soils in the Burdekin Delta.



$y = -0.56 + 0.96x$ ($r^2 = 0.99$, $p < 0.01$. P = plant, 1R = first ratoon. Assumes 0.1 ML/ha/irrigation tail water loss.

3.2 On-Farm Trial Results

A reduced cultivation and furrow shape trial was established on a grower's property where water monitoring had shown very low irrigation efficiency (<20%) the year before (Table 3). The reduced and conventional tillage treatments were installed just after the crop was planted and the 'U' and 'V' shaped furrows were put into each of the tillage treatments at hill-up. All treatments received the same amount of fertiliser.

Even before the furrow shapes were installed at hill-up, the reduced tillage treatment had saved approximately 5 ML/ha (Table 3). After hill-up, the treatment that used the least water was the reduced tillage plus narrow 'V' furrows. At the end of the season, there was a saving of nearly 15 ML/ha between this treatment and the conventional tillage treatment plus broad 'U' furrows. Water use was generally halved with the narrower furrow within the tillage treatments. This agrees with previous trials conducted by BSES.

Table 3. The effect of furrow shape and cultivation practices on irrigation water usage of sugarcane grown on an alluvial soil.

Tillage Practice	*Reduced Cultivation (ML/ha)*		*Conventional Cultivation (ML/ha)*	
Total before hill-up (3 irrigations)	5.18		10.74	
Furrow Shape	Broad U	Narrow V	Broad U	Narrow V
9/11/96	3.21	1.60	4.28	2.64
26/12/96	4.30	1.98	5.90	2.40
18/03/97	1.09	0.78	0.84	0.70
14/04/97	1.17	0.49	3.10	0.65
3/05/97	0.79	0.53	0.60	0.42
Total	15.74	10.56	25.46	17.55
ML/ha/irrigation	1.97	1.32	3.18	2.19
Cost differential/ha	-$47	- $137	$0.00	- $140

Experiment was a plant crop on a sandy loam soil, with readily available water content of 0.4 ML/ha. Inflow rate of irrigation water was 0.6 l/s. Cost of Burdekin Delta underground water assumed to be $18/ML (ref. Canegrowers). Reduced cultivation included one residual herbicide spray plus two cultivations after planting. Conventional cultivation was seven cultivations after planting.

The most economical treatments were both 'V' shaped furrow treatments in the conventional and reduced cultivation treatments, both of which saved around $140/ha. However, these costings do not include any labour costs. Substantial savings could be made in this area with reduced cultivation practices. The main disadvantage of the reduced tillage practice is that at least one herbicide has to be used to control weeds. This is usually a residual herbicide, usually a mixture of atrazine and ametryn.

There was no effect on yield from any of the treatments.

Two other trials were established in the 1996/97 irrigation season. Table 4 demonstrates the results from a reduced tillage trial established on a monitoring site with irrigation efficiencies of around 50%. Table 5 shows results from a furrow shape trial on the same monitoring site.

Table 4 demonstrates that a saving of nearly 2.5 ML/ha/year was achieved with reduced cultivation. This alluvial soil was less freely draining than the soil type in Table 3, and the grower was using higher inflow rates on both treatments; therefore the water saving was much less, but not insignificant. In this case, the conventional cultivation treatment was cheaper than the reduced tillage treatment, which had two blanket sprays. However, since one person runs this farm, there would have been considerable time and labour savings. There were no yield differences between the two tillage treatments.

Table 4. The effect of cultivation practices on irrigation water usage of sugarcane grown on an alluvial soil.

Tillage Practice	*Reduced Cultivation*	*Conventional Cultivation*
Total water applied (ML/ha)	15.73	18.15
ML/ha/irrigation	1.21	1.45
Irrigation application efficiency (%)	57.8	48.3
Cost differential/ha	+$75.00	$ 0.00
Yield (tonnes sugar/ha)	25.00	25.27

Experiment was a plant crop on clay loam soil, with readily available water content of 0.7 ML/ha. Reduced cultivation included two blanket herbicide sprays plus three cultivations after planting. Conventional cultivation was six cultivations after planting. Cost of Burdekin Delta underground water assumed to be $18/ML (ref. Canegrowers).

Table 5 shows that on the same alluvial soil type as the reduced tillage trial in Table 4, water savings of around 1.7 ML/ha/year are possible with the 'V' shape furrow. As this treatment is no more expensive than the broad 'U' shape furrow a saving of over $30/ha was achieved from reduced pumping and maintenance costs.

Table 5. The effect of furrow shape on irrigation water usage of sugarcane grown on an alluvial soil.

Furrow Shape	*Conventional U*	*Narrow V*	*Modified V*
Total water applied (ML/ha)	12.48	10.80	10.80
ML/ha/irrigation	1.56	1.35	1.35
Irrigation application efficiency (%)	44.8	51.9	51.9
Cost differential/ha	$0.00	- $30.25	- $30.25
Yield (tonnes sugar/ha)	22.18	20.90	21.81
Soil in the cane supply (%)	0-1	2-5	0-1

Experiment was a late plant crop on clay loam soil, with readily available water content of 0.7 ML/ha. Cost of Burdekin Delta underground water assumed to be $18/ML (ref. Canegrowers).

There does seem to be a slight yield reduction from the 'V' shaped furrow. The reason for this is unclear, and this is the only trial conducted so far in the Burdekin where a yield reduction from 'V' shaped furrows has been seen. The modified 'V' furrow does not seem to have decreased yield.

The modified 'V' was tested because growers and harvesting contractors have expressed some concern that cane grown using a deep 'V' shape furrow may be more difficult to harvest than the conventional broad 'U' shape. They state that the harvester does not track well in the narrow furrows and it is thought that there may be a higher soil intake to the mill with this furrow shape.

Figure 2 shows that the modified furrow shape had a flatter bottom to the furrow allowing the harvester wheel to fit into the interspace better. The furrow shapes were achieved using hilling-up boards running flat for the broad 'U' shape furrow, tilted forwards for the 'V' shape furrow and the modified 'V' shaped furrow. Running two closely spaced spring tines down the centre of the furrow created the flatter bottom of the modified 'V'. The results in Table 5 show that the modified 'V' used the same amount of water as the narrow 'V' furrow.

However, there was a higher percentage of soil in the cane supply with the 'V' shaped furrow compared with the conventional 'U' shape. This increase in soil was overcome by the modified 'V' furrow, which gave the same water savings as the normal 'V'.

Figure 2. Row profiles of (a) broad 'U' shaped furrow, (b) narrow 'V' shaped furrow and (c) modified 'V' shaped furrow.

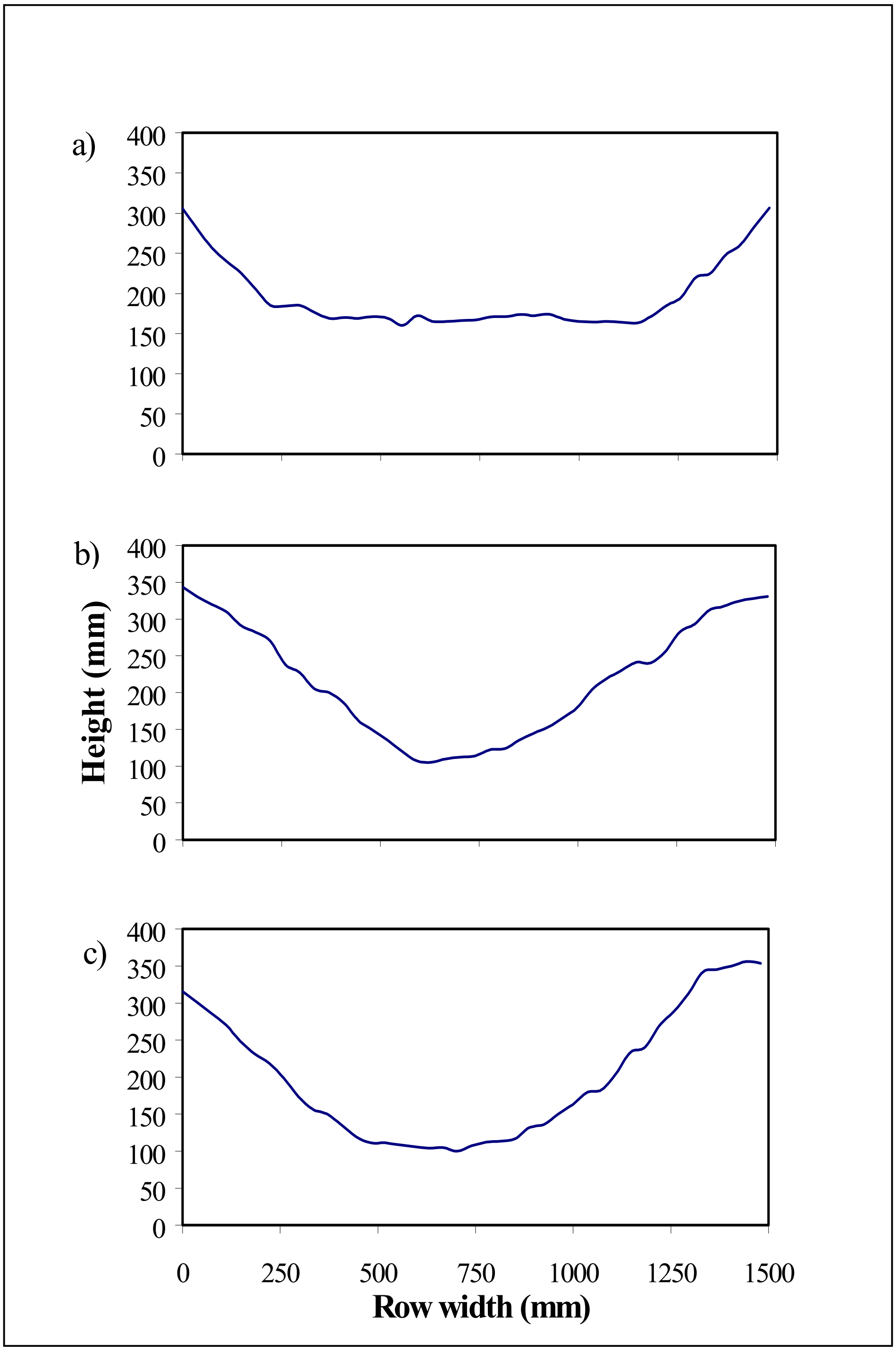


Table 6 shows an example of individual irrigation monitoring on a freely draining sandy loam soil. It highlights that using the correct inflow rate, reduced tillage and 'V' shaped furrows, furrow irrigation efficiencies can be reasonable, even on very sandy soils. An adjacent monitoring site with the same soil type, but with 'U' shape furrows, low inflow rates and conventional cultivation, produced an irrigation efficiency of less than 20%.

Table 6. Irrigation water use of a sugarcane plant crop grown in the Burdekin Delta on an alluvial soil.

Irrigation No.	*ML/ha applied*	*Irrigation application efficiency (%)*
1	0.62	64.5
2	0.57	70.1
3	0.99	40.4
4	0.85	47.1
5	1.13	35.4
6	1.17	34.2
7	0.68	58.8
8	0.49	81.6
9	0.50	80.0
10	0.91	44.0
11	0.71	56.4
12	0.50	80.0
13	0.42	95.2
14	0.62	64.5
15	0.49	81.6
16	0.67	60.0
17	0.68	59.0
18	0.41	97.6
19	0.96	41.7
20	0.77	52.0
21	0.60	66.7
Average	**0.70**	**62.4**
Total	**14.74**	

Experiment was March plant crop on a sandy loam soil, with readily available water content of 0.4 ML/ha. Inflow rate of irrigation water was 2.5 l/s.

3.3 Survey Results

BSES extension staff in the Burdekin conducted the two surveys. Growers from both the Burdekin Delta and the Burdekin River Irrigation Area (BRIA) were asked questions relating to their irrigation practices at the start and end of the project. A summary of the results follows.

3.3.1 Amount of irrigation water applied

In 1995, 75% of BRIA growers knew how much water they applied each year. The reason for this was because the Department of Natural Resources meter all BRIA farms. Once again in the 1997 survey, the level of understanding of water use in the BRIA was at 75%. In the BRIA total water use for the 1994/95 season was 11.9 ML/ha and in the 1996/97 season, 9.6 ML/ha. This reduction in water use between the two seasons was probably because the 1996/97 season was much wetter than 1994/95 (991 mm cf. 399 mm).

Very few Delta growers have access to water meters, so they were generally unaware of their water use in both surveys.

3.3.2 Water use efficiency

Water use efficiency (WUE) is defined as tonnes of cane produced per hectare, divided by total irrigation and effective rainfall (t/ML). WUE seemed to be generally understood as a concept, but growers were generally not using the term to monitor how efficiently they are applying their irrigations. The reason for the lack of adoption of this term in the Delta is related to the fact that growers do not know how much water they are applying. The reason that growers in the BRIA are not using WUE as a benchmark may relate to the difficulty in calculating effective rainfall. In general WUE may not be perceived as being very useful.

In the second survey, we asked what growers were doing to improve their WUE's (Table 7).

Table 7. Percentage of Burdekin growers changing management practices to improve water use efficiency (1997 survey).

Management practices	*BRIA %*	*Delta %*
Changed furrow shape	53	52
Reduced tillage	61	24
Mixing irrigation water	15	36
Using surface gypsum	53	36
Changing flow rates	38	20
Installed a tailwater recycling pit	46	8

BRIA refers to Burdekin River Irrigation Area

In the 1997 survey, we found that 68% of growers in the Delta and 8% of BRIA growers were having problems getting water to the end of the drill. This is because of the freely draining nature of the alluvial soils on the Delta. The BRIA growers having difficulty getting water through would probably be located on alluvial soils close to the Burdekin and Haughton Rivers. For the largest part, Delta growers have changed their furrow shapes to narrow 'V's and in the BRIA, growers use a broad 'U' shape to maximise water soakage into the hill, especially on the low infiltration sodic soils.

Growers also seem to be reducing cultivations. This is particularly true of BRIA farmers (Table 7). Our trials on freely draining soils have shown that reducing tillage passes in plant crops can save between 1.7 and 10 ML/ha/year. The adoption of this practice has certainly increased irrigation efficiencies on these soils.

The practice of mixing surface and underground irrigation water supplies has increased in the Delta as growers get greater access to open water. Salinity of some underground water in the Delta has made management more difficult especially where salinity levels have risen during the less than average rainfall years since 1991. Both North and South Burdekin Water Boards have increased pumping from the Burdekin River allowing the use of surface water for direct irrigation.

In the BRIA, surface gypsum is mainly being used to ameliorate sodic soils. In the Delta, growers are using gypsum in preference to lime products to improve poor water penetration on some alluvial soils, without raising pH. Improved water penetration leads to improved WUE by increasing soil moisture storage and availability to the crop while reducing runoff.

On freely draining soils, increasing flow rates will generally shorten the time the water takes to get to the end of the row. If this practice is used in combination with a narrow ‘V’ furrow (and reduced tillage), deep drainage losses will be minimised, thus improving WUE.

It is encouraging to see the number of recycling pits being installed in the BRIA and to a lesser extent in the Delta. As the cost of water rises in the BRIA, recycling tailwater will become more popular. Environmental pressure to contain tailwater will also see an increase in this practice.

3.3.3 Evaporation minipans

The ‘Water Check’ project (funded by SRDC) is the main impetus behind the adoption of evaporation minipans for scheduling furrow irrigations, although minipans were promoted at every opportunity during this project. Minipans were used for irrigation scheduling at all our trial and water monitoring sites.

In the first survey we asked growers whether they used minipans for irrigation scheduling. Seventy per cent of BRIA growers asked, said that they were using minipans, although only 4% of Delta growers were using them at the time. However 80% of the growers who were not using them, said they would try minipans the next season. The results in Table 8, show that in the final survey, 83% of BRIA growers and 48% of Delta growers have now adopted minipans. At the end of the project, we had distributed over 500 minipans to Burdekin growers (there are approximately 850 growers in the Burdekin).

Table 8. Percentage of Burdekin growers using evaporation minipans

District	*1994/95*	*1996/97*
BRIA	70	83
Delta	4	48
Total	24	62

BRIA refers to the Burdekin River Irrigation Area

3.3.4 Irrigation benchmarking

Data collected from both surveys, from the water-use monitoring and irrigation trials in the Delta, have enabled us to establish the following irrigation and production benchmarks for furrow irrigation in the Burdekin.

BRIA
- 1.0 ML/ha/irrigation
- 10-12 ML/ha/year
- 10 tonnes of cane/ML total water
- 115 tonnes of cane/ha
- 17-18 tonnes of sugar/ha

Delta
- 1.5-2.0 ML/ha/irrigation (plant crops)
- 1.0-1.5 ML/ha/irrigation (ratoon crops)
- 20-35 ML/ha/year
- 4-5 tonnes of cane/ML total water
- 125 tonnes of cane/ha
- 18-19 tonnes of sugar/ha

Average of 4-5 ML/year of effective rainfall

In the BRIA, efficiencies are generally good, although growers with tail-water recycling should be able to achieve water use efficiencies of 12 tonnes of cane/ML and irrigation application efficiencies of more than 80%. These figures should be the target of BRIA growers.

In the Delta, growers should be able to achieve an average efficiency of 60%. Total irrigation water use should then not exceed 16 ML/ha/year. Therefore, water use efficiencies of 6 tonnes/ML of total water are readily achievable for Burdekin Delta growers.

4.0 CONCLUSIONS

4.1 Effect of 'Increasing Irrigation Efficiencies in the Australian Sugar Industry' on Water Use Efficiencies

4.1.1 Furrow shape

Fifty per cent of Burdekin Delta growers are trying 'V' shape furrows because of the project (approximately 270 growers). The water savings from changing furrow shape are at best 15 ML/ha/season and at worse 2-3 ML/ha/season. Raine and Bakker (1996) previously found a 50% reduction in water use with V shaped furrows in the Burdekin. Therefore we can presume a conservative saving of 5 ML/ha/season. This has increased WUE from 4.5 t/ML to 5.4 t/ML (0.9 t/ML) over 20% of the furrow irrigated area in Queensland.

4.1.2 Reduced tillage

On the Delta over 20% of growers have reduced tillage. Our trials showed water savings of between 7 and 10 ML/ha/season in plant crops. BS90S trials showed water savings in ratoon crops of 2 ML/ha/season. If we presume a saving of just 1 ML/ha/season for reduced tillage, this is an increase in WUE of 0.2 t/ML over 6% of the furrow irrigated area.

4.1.3 Evaporation minipans

Minipans have increased productivity without generally using any extra water. A survey of 37 minipan users showed an increase in WUE of 0.5 t/ML. Approximately 400 growers are using minipans in the Burdekin. This accounts for 31% of the furrow-irrigated area.

4.1.4 Total improvement in WUE

An improvement in WUE of 0.61 t/ML (weighed average) over nearly 20% of the total furrow irrigated area. This does not include WUE improvements in other areas, eg Mareeba and Bundaberg, where minipans and tensiometers are being used for scheduling and 'V' shape furrows are being promoted.

4.2 Effect of 'Increasing Irrigation Efficiencies in the Australian Sugar Industry' on Irrigation Water Use.

4.2.1 Furrow shape

A reduction of 5 ML/ha/season over 20% of the furrow irrigated area in Queensland (see 4.1.1).

4.2.2 Reduced tillage

1 ML/ha/season saving over 6% of the furrow irrigated area (see 4.1.2).

4.2.3 Total water use savings

Nearly 25% of furrow irrigated canefields in Queensland have a reduced water usage by well over 1 ML/ha. This does not include water savings from other areas that BSE2 has affected.

4.3 Irrigation Technology Transfer Framework

This project used a technology transfer model incorporating small grower cell groups and participatory action learning. From the outset of the project, growers were involved in discussions with each other and BSES staff, collecting water use data, measuring cane growth and helping to run on-farm trials. This method of technology transfer has shown to be very successful, as the adoption rates of the new irrigation practices show. We felt that one of the most important factors in ensuring rapid adoption of new technology was to let the growers chose which practices they would like to try and so there was ownership of the new practices from the start. This is not a novel approach to technology transfer and we are not alone in using it. The following list of steps is being used to encourage growers to adopt better irrigation practices in the irrigated crops of South Australia.

Six Steps to Improve Irrigation (after Tony Thompson, Primary Industries, South Australia).

Step 1 Irrigation awareness and form groups of irrigators

Then each irrigator:

Step 2 Records and compares with other group members
Step 3 Participates in irrigation workshops and compares his practices
Step 4 Evaluates and improves both his irrigation system and his irrigation management
Step 5 Installs equipment to monitor (eg soil moisture)
Step 6 Uses monitored data to optimise $ per unit of water

This approach is essentially the same as the method of: **Awareness, Participation, Evaluation** used in this project.

4.4 Cost:Benefit Analysis for the Burdekin Sugar Industry

The overall water savings for the Burdekin may amount to over 100,000 ML/year from reduced tillage and 'V' shape furrows (see 4.1.1 and 4.1.2). This is worth $1.8 million to Delta growers per annum in reduced pumping and maintenance costs. It is also worth $1.4 million per year to the North and South Burdekin Water Boards in reduced pumping and maintenance costs for supplying open water to Delta growers and for pumping river water to recharge the aquifer.

The adoption of minipans (even though not a major part of this project) has led to an increase in productivity of around 1.0 tonne of sugar/ha (Holden, Shultz and Kelsey, 1996). Since over 60% of Burdekin growers have adopted minipans, we can assume an increase in production of 39,000 tonnes of sugar with no extra water being used. This is worth nearly $12.5 million in extra revenue to growers. The total project cost was $205,000 to LWRRDC, BSES, South and North Burdekin Water Boards, QDPI and the sugar industry. Therefore the cost:benefit ratio of this project is 1:77 for the Burdekin.

Assumptions: Underground water costs $18/ML to growers in pumping and maintenance costs.
It costs the water boards approximately $14/ML for open water in pumping and maintenance costs.
Sugar is worth $320 per tonne.
The cropped area in the Burdekin is 65,000 ha (40,000 ha in the Delta and 25,000 ha in the BRIA)

4.5 Overall Conclusions and Recommendations

All of the specific objectives of this project have been met (see 1.0). Much of the success of the project can be related back to the participatory action learning process used as a part of the technology transfer. The project also used simple extension tools that the growers could use and understand, such as the evaporation minipan for irrigation scheduling and the in-flume water meters for measuring water usage. This project has highlighted the necessity to measure water use. If it cannot be measured, it cannot be improved.

The increase in soil in the cane supply from the 'V' shaped furrow is of concern. However, the modified 'V', which can be easily formed using spring tines behind the hilling-up boards is one possible solution. This furrow shape needs to be further tested on a range of soil-types to ensure that it is as efficient in reducing deep-drainage losses as the normal 'V'.

Alternate furrow and surge irrigation need to be tested under Australian conditions as they could both potentially increase furrow efficiencies of freely draining soils.

The term 'water use efficiency' is a good benchmark figure for assessing the efficiency of irrigations as it takes into account not only water use but also production. However, even though growers seem quite conversant with the term, they do not seem to be using it. We have tried to use the benchmark of 10 tonnes of cane per ML of total water applied. This figure is readily achievable with furrow irrigation. However, we cannot expect growers to calculate their own effective rainfall if researchers cannot agree on the best way to calculate it themselves. There are two sugarcane growth models (APSIM and QCANE) that calculate effective rainfall, although growers will probably never have ready access to these models. For the WUE benchmark to succeed in sugarcane, effective rainfall data needs to be published and therefore readily available to growers at the end of each irrigation season. We also need to promote the term widely throughout the irrigated section of the industry, and there must be continuity of the term and the way it is calculated in all irrigation districts.

5.0 ACKNOWLEDGMENTS

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6.0 REFERENCES

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APPENDIX 1

PROJECT OUTPUTS

1. Publications

Shannon, E L, and Raine, S R (1995). Changing furrow shape saves water. *BSES Bulletin* No 52, p. 22.

Holden, James. 1996. Water use efficiency, how do you compare? *BSES Bulletin* No 55, pp. 6-7.

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Raine, S R, Holden, J R, and Shannon, E L 1996. Getting the message across in the battle for irrigation efficiency. Proceedings of the 1996 Conference on Engineering in Agriculture and Food Processing, paper no. SEAg 96/092.

Holden, James, Shultz, Rod, and Kelsey, Kimberley 1997. ‘Water Check’ - improving water use efficiencies in the Burdekin. *Australian Sugarcane Magazine* V1 No1, pp. 35-38.

Various Authors. 1997. Irrigation of Sugarcane. BSES/SRDC publication.

Increasing furrow irrigation efficiency in the Australian sugar industry. 1997. BSES video.

2. Field Days

1996 BSES Field Day	Burdekin
1997 BSES Field Days	Burdekin & Herbert
1997 FNQ Field Day	Mareeba

Bus tour and field day at trial sites (May 1997)

3. Shedmeetings/Grower Groups

1995
September (1)
October (2)
November (4)
December (5)
1996
February (1)
April (2)
May (4)
June (1)
July (1)
November (12)
October (2)
1997
February (9)

Figures in brackets indicate number of meetings that month.

4. Irrigation Workshops (BSES extension and Cane Protection and Productivity Board staff)

1995
Burdekin (44 attended)
Bundaberg (14 attended)

1996
Proserpine (50 attended)

APPENDIX 2

BURDEKIN CANEGROWERS' SURVEY
AUGUST 1995

Restrictions to Adoption of Improved Irrigation Technology

GROWER ____

FARM LOCATION ________________________________ Delta ☐

____ BRIA ☐

(if both, indicate % of each area)

How long have you worked on the farm? _________

Area Harvested 1995 ________________

Area Harvested 1990 ________________

Tonnes cane to be harvested 1995 ________________

Tonnes cane harvested 1990 ________________

SUPPLY

What proportion of your irrigation water comes from :

bores _____________
waterboard channel _____________
QWRC _____________

Do you know the megalitres (ML) of irrigation water used on your farm in 1994? Yes / No

What was your water consumption in 1994 in ML/ha? _____________
or, do not know _____________

Do you know how many tonnes of cane you produced per ML of irrigation water

Yes (state figures) ____________ (tonnes per ML)
No

What are the flow rates of each of your pumps/bores/QWRC outlets? __________

If an open water user, what is your nominal allocation from QWRC or waterboard channels? _________________________

What quantity of QWRC water was used in 1994? _____________

FARM LAYOUT

When was your farm developed for cane production? ___________________

Has your farm been developed from a formal plan? Yes
No

What were the major considerations in your farm layout? (eg row lengths, slope, soil type, ease of irrigating, direction of burning) ______________________________

How important was irrigation management in this decision? (Expand if possible)

1. Most Important ____
2. Important ____
3. Not Important ____

SOIL WATER

What are the main soil types on your farm? ___________________________________

What is the irrigation interval during summer for the main soil types on your farm?

____

WATER QUALITY

How would you describe the quality of your irrigation supplies?

Pump/bore ______________________________________
Don't know

(a)	______	ds/M	or	______	grains/gallon
(b)	______	ds/M	or	______	grains/gallon
(c)	______	ds/M	or	______	grains/gallon
(d)	______	ds/M	or	______	grains/gallon
QWRC Channel	______	ds/M	or	______	grains/gallon
Water Board	______	ds/M	or	______	grains/gallon

What is the optimum water quality for irrigating on your farm?

____

Do you blend the quality of your bores? If so, at what quality?

____

FLOW RATES

Describe a typical irrigation event (no. of hours in summer months) on your farm?

____

Do you have difficulty getting water to the end of the furrows? Yes
No

If yes, describe the usual circumstances? (time of year, crop type, rainfall incidence, soil types, row length, etc.)

____

Have you had difficulties getting irrigation water to soak into the hills? Yes
No

If yes, what proportion of your farm has problems with soakage? ____________

Do you use lime or gypsum and if so what type and rates? __________________

Do you change individual cups or use gate values? ________________________

TILLAGE PRACTICES

Briefly describe your typical ground preparation for planting, and tillage practices before hilling up.

____

What is your usual ratooning practice?

____

Have your tillage practices in either plant or ratoon crops changed over the past five years?

____

If so, please detail the alterations? ___________________________________

What changes would you consider making in future?

____

BURNING

What proportion of the harvested area in 1994, had tops burnt? ______________

Under what circumstances do you burn tops? _____________________________

Have you ever cut your crop green? Yes
No

If so, year and % ____________________

What are the main limitations to green cane harvesting on your farm?

____

SCHEDULING

How do you determine when a block should be irrigated?
(experience, evaporation minipan, when pump available, etc.)

____

Have you used an evaporation minipan? Yes/No

Would you consider using one in future? Yes/No

If not, why not? ____

Do you take notice of the irrigation report on the ABC radio? Yes/No

APPENDIX 3

BURDEKIN CANEGROWERS' IRRIGATION SURVEY
JULY 1997

Name: ……………………………………. **DELTA:** ☐

Farm Location: …………………………. **BRIA:** ☐

1. What proportion of irrigation water comes from:

Bores ______
Waterboard channel ______
QWRC ______

2. Do you use a flow meter to monitor how much water is applied per field? Yes __________ No __________

In NO then how do you determine wateruse?

____

3. What was you water consumption in the past season in ML/ha?

____

4. Do you know how many tonnes of cane you produced per ML of irrigaiton water?

____

Average estimate ___________ t/ML

5. How do you determine when a block should be irrigated?

Use experience ______________
Evaporation minipan ______________
When pump available ______________
Set interval ______________
Other ______________

6. What is the irrigation interval during summer and winter for the main soil types on your farm?

Summer ____________________________________
Winter ____________________________________

IF YOU USE THE EVAPORATION MINIPAN THEN:

7. Have you experienced higher yields since using the minipan?
Yes _________ No _________ Do not know __________

8. Do you use more or less water now compared to when you did not use the minipan?

More ____________ Less __________ Do not know ___________

9. Do you (or did you) have difficulty in getting water to the end of the furrow? Yes _______ No _______

10. Have you tried any new technique to improve irrigation efficiency? Yes _________
No _________

IF YES	**EFFECT ON IRRIGATION EFFICIENCY** **IMPROVED**	**NO EFFECT**
Changed furrow shape	……………………………..	……………………………..
Reduced tillage	……………………………..	……………………………..
Applied surface gypsum	……………………………..	……………………………..
Used dissolvenator	……………………………..	……………………………..
Changed flow rate into furrow	……………………………..	……………………………..
Mixed irrigation water	……………………………..	……………………………..
Introduced recycling pit	……………………………..	……………………………..

11. Do you harvest any green cane? Yes ________ No ________ % of farm _________%
Do you farm with GCTB? Yes ________ No ________

IF YES: Do you find that it is more difficult to irrigate a trash blanket? Yes __________
No __________

	YES	**NO**
Use more water	……………...	……………...
Can't get water to end of furrow	………………	……………...
Water breaks across furrows	………………	……………...
Field gets waterlogged	………………	……………...

12. Do you think that you can improve on your current irrigation method(s) and use less water?
Yes _____________ No ___________

If yes, how do you think you could achieve this?

____