

**BUREAU OF SUGAR EXPERIMENT STATIONS
QUEENSLAND, AUSTRALIA**

**FINAL REPORT
SRDC PROJECT BS127S (WATER CHECK)
INCREASED ADOPTION OF EFFICIENT
SUSTAINABLE IRRIGATION PRACTICES
BY AUSTRALIAN CANEGROWERS**

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SUMMARY

The SRDC/BSES funded 'Water Check' project was completed in June 1997. One of the main aims of the three year irrigation extension project was to improve the water use efficiency (WUE: tonnes of cane per megalitre of total water applied) of Queensland canegrowers. This was achieved using grower groups, especially in the Burdekin and Bundaberg districts. The extension method was based on action-learning principles which included growers collecting their own water use efficiencies and grower involvement with on-farm trials and demonstrations.

In Bundaberg, since the start of the 'Water Check' project there has been an increase in WUE over the whole district of 0.9 t/ML (9.6-10.5 t/ML). A better understanding of the water holding capacities of the Bundaberg soils is a highlight of the Water Check project.

Irrigation scheduling with evaporation minipans in the Burdekin has increased production without generally using any extra water. The WUE of minipan users increased on average by 0.5 t/ML (7.8-8.3 t/ML). At least 400 growers are using minipans in the Burdekin and over 800 minipans have been distributed statewide. WUE's have also been increased on freely draining furrow-irrigated soils by the implementation of 'V' shape furrows and reduced tillage.

The success of Water Check was due to the good research data available for extension, the use of simple tools such as the minipan and the participatory action-learning extension method used.

1.0 INTRODUCTION

1.1 Broad aims and objectives

SRDC (Sugar Research and Development Corporation) funded the three-year project 'Increased Adoption of Efficient, Sustainable Irrigation Practices by Australian Canegrowers in July 1994.

The broad objectives of the project were to:

- Determine perceived limits to adoption of more efficient irrigation practices.
- Increase grower awareness of the benefits of more efficient water use.
- Research and develop a technical package for more efficient irrigation techniques.
- Demonstrate and promote best irrigation practice for irrigation of sugarcane.

The overall aim was to: 'improve productivity, profitability and sustainability of canegrowing through increased adoption of efficient irrigation techniques by Australian canegrowers.'

1.2 Industry significance

At the start of the project in 1994, forty percent of Australian sugarcane was produced from irrigated land. Australian sugar production from irrigated land now stands at sixty percent. Irrigation is therefore critical to sustain or expand sugar production. More efficient use of irrigation water has a direct impact on profitability and productivity, especially with increasing irrigation costs and limited water supplies.

More efficient irrigation practices reduce deep drainage accession to groundwaters, thus reducing the potential for leaching of pesticides and nutrients and reducing the likelihood of waterlogging and salinisation in districts where irrigation is important. These issues are important because of the potential for raised watertables. Most irrigated cane areas are also near to environmentally sensitive areas such as the Great Barrier Reef.

At the start of the project there was considerable potential for improvement in water use efficiency (WUE) in sugarcane. In 1994, the average WUE was 7.9 tonnes of cane/ML for commercially grown cane. In field-scale trials, WUE's of 12-15 tonnes/ML had been achieved. There was a clear need to close this gap.

Barriers to the adoption of more efficient irrigation practices were poorly understood. There was little attention being paid to application efficiencies and generally very few growers were using irrigation scheduling tools.

Innovative methods were needed to increase the adoption of efficient irrigation practices by growers.

1.3 Outputs

- An improved understanding of the socio-economic factors that influence adoption of more efficient irrigation practices.

- Clearer specification of best irrigation practices for each region.
- Extension methodology that is responsive to the socio-economic factors identified.
- Greater grower awareness of the benefits of more efficient water use.
- A published technical package describing methods for raising irrigation efficiency.
- On-farm demonstrations of best irrigation practice.

1.4 Outcomes

- Increased water use efficiency (WUE) of 1 tonne of cane/ML by 25% of canegrowers using irrigation.
- More sustainable irrigated cane production and reduced impact on the environment in irrigated canegrowing areas.

2.0 METHODS

The project focussed on grower participatory or action-learning techniques from the outset. It was important that growers felt that they had ownership of the project and that the project was addressing issues that they felt were important in their own districts. The participatory technique used in 'Water Check' was as follows:

1. Key grower invited peers to attend irrigation focus group.
2. Identification of the irrigation difficulties/problems in the district with grower groups.
3. Establish data collection sites with interested growers in the groups.
4. BSES staff or preferably the participating grower presented local data to grower groups.
5. New management techniques tried by growers in the group.
6. Feedback of results to group.

2.1 Burdekin

In the Burdekin District of North Queensland, the project concentrated on the adoption of irrigation scheduling using the evaporation minipan and improving irrigation application efficiencies. Much of the latter was conducted in conjunction with the Land and Water Resources Research and Development Corporation (LWRRDC) funded project 'Increasing Irrigation Efficiencies in the Australian Sugar Industry'.

2.1.1 Irrigation scheduling

Before the start of the 'Water Check' project, most growers in the Burdekin did not practice irrigation scheduling using a crop related tool. The most common practice was grower experience or irrigating on a set schedule.

Burdekin extension staff had promoted irrigation scheduling charts in the late 1980s. These comprised of a chart with a column for each field based on an estimated water holding capacity. After the field was irrigated, a pin was placed at the top of the column and moved down each day depending on 'Class A' pan evaporation and a crop factor. Growers could receive this data by telephoning into the Burdekin Sugar Experiment Station (free of charge).

Unfortunately, the campaign was not successful. The reason for the lack of adoption was largely due to the perceived complexity of the chart by the growers. Only a very small number of growers accessed the evaporation data. The estimated water holding capacities of Burdekin soils were also found to be inaccurate. It was concluded that a simpler and more grower-friendly model was needed. This was confirmed by a local grower who stated that he wanted something that he could drive up to each evening that would give him a guide to when to start irrigating.

The pasture industry was already using a simple 'evaporimeter' made from a cut-down metal or plastic 200 litre drum (Turner, 1989). This gave the idea for the evaporation minipan. The minipans were originally made from cut-down metal drums, but these rusted out rapidly and were replaced by plastic drums.

Minipans were first introduced to Burdekin canegrowers in 1991, although a coordinated approach to the adoption of minipans for irrigation scheduling did not occur until the start of the 'Water Check' project.

Initially, irrigation deficits were calculated for the minipan based on estimates of the readily available water held by Burdekin soils. It became apparent that these estimates needed refining. The calibration procedure was introduced to improve the accuracy of the minipans. Growers were encouraged to conduct their own calibrations for soil type at the grower meetings.

The procedure was:

1. Twenty-five stalks were marked out in a fully closed-in crop and the height of the stalks was recorded to the top visible dewlap (a plastic cap was placed at the base of each stalk as a reference point to measure from).
2. The field was irrigated and the minipan was filled with water.
3. Stalk height and minipan evaporation was recorded daily (these measurements commenced two to three days after irrigation to allow the soil to reach field capacity).
4. When the daily growth rate dropped to 50% of the maximum recorded, the drawdown level in the minipan was noted. This became the irrigation deficit.
5. The procedure need only be completed once for each soil type on the farm.

Using 50% of the maximum-recorded crop growth rate to establish the irrigation deficit is an arbitrary value that may approximate readily available water in the soil. Between 1995 and 1997 minipan evaporation was compared with 'Class A' pan evaporation to evaluate how closely minipan irrigation deficits compared to established readily available soil moisture. It was recommended that the minipan only be used for scheduling irrigations for fully closed-in, actively growing crops.

The minipans were provided free of charge with measuring sticks. The recommendations for their set-up were as follows:

1. Install the minipan on concrete/masonry blocks to allow air to circulate under the pan.
2. If animals are likely to drink out of the minipan, place it on a 200 litre drum.

3. The minipan should be close to a water supply for easy filling but not so close to a pump or cylinder that may splash water into the pan or raise the humidity of the air around the pan. The pan should be located no closer than 5 metres from the canefield or any object that blocks the air-current over the minipan.

2.2 Bundaberg/Isis

2.2.1 1994/95

The outlook for the 1994/95 growing season was favourable. The irrigation allocation was initially established at 100%. Later in the season, the allocation was increased to 110%.

In the first year of Water Check in the southern districts of Bundaberg and Isis, the main aim of the project was to measure the readily available soil moisture of the different soil types in the area. This information was needed so growers knew how much water to apply at each irrigation event hence reducing water losses due to deep drainage or runoff.

Project staff measured soil moisture with a neutron probe, and then related moisture to stalk growth. The readily available moisture in the soil was determined by subtracting the soil water at the half growth point of the crop from the full point (field capacity).

Twenty sites were established in the Bundaberg/Isis area to determine readily available moisture on all of the main soil types, *viz*: sands, gleyed podzolics, yellow podzolics, red podzolics, red volcanics, black earths and alluvial soils.

As part of the Water Check activities, the application of winch, drip and furrow irrigation systems were investigated in the Bundaberg district. This was achieved by determining the quantity of irrigation water removed by the cane plant as a proportion of the total water applied by irrigation.

More than 40 growers in the first year participated in stalk growth measurements for tensiometer or minipan calibrations.

Tensiometers reflect the force that plants need to exert to obtain moisture from the soil. As the soil dries out, a very small amount of water moves into the soil from the tensiometer through a ceramic tip. The loss of water creates a vacuum in the tensiometer and is recorded as a vacuum reading. The higher the reading, the drier the soil. Irrigation begins again when the tensiometer gauge reaches a predetermined level. After irrigation or rainfall, water moves back through the ceramic tip and the vacuum level drops in the tensiometer. In the same way as minipans, tensiometers can be calibrated to crop growth rates for different soil types.

Water Check guidelines for the use of tensiometers for irrigation scheduling.

- Tensiometers should be installed to a depth of 60 cm in the plant line except in sandy or shallow soils where they should be installed to a depth of 30cm.
- Tensiometers need to be installed carefully and maintained regularly to ensure that they do not run out of water.

- Two per site gives more accuracy (one at 30cm and one at 60cm).
- Cane to be measured should have about 1 m of stalk growth (the canopy should be closed).
- Once growth rates fall to 50% of the maximum recorded in that irrigation, the tensiometer reading is recorded. This becomes the deficit figure.
- Daily readings are recommended for greater accuracy.

During the 1994/95 season it became apparent that more information was needed on trickle irrigation wetting patterns, as the wetted area determines the amount of water held by the soil. This amount of water can then be related to the number of pumping hours before water is lost from the profile by deep drainage.

2.2.2 1995/96

The outlook for the water year in the southern region was bleak with only 35% of allocation available to growers up until Christmas 1995. With this in mind Water Check and other BSES staff made the following recommendations:

- Harvest green and retain the trash if possible.
- Irrigate to establish ratoons and after fertiliser application.
- Concentrate the remaining water on the most profitable blocks (most likely to be plant and first ratoon).

After some good rainfall events in the later part of 1995, allocations were lifted gradually through the season. Most growers ended the season on between 60% and 90% of allocation, plus some out of allocation water.

The main thrust for the Water Check project in the second year was to make the best use of the limited water resource. To do this several monitoring sites were set up in trash blanketed and trickle irrigated blocks. These sites included:

- Stalk growth measurements of a late-season irrigation trial.
- Alternate drip irrigation compared with every-row drip irrigation including growth measurements and neutron probe readings.
- Drip irrigation wetting pattern trial using Time Domain Reflectometry (TDR) equipment.

Approximately 10 growers calibrated tensiometers or minipans on their own farms with stalk growth measurements.

An irrigation survey was sent to 70 growers in total from the four mill areas to ascertain their irrigation practices and perceptions and to determine the factors affecting irrigation efficiency.

2.2.3 1996/97

In the final year of the Water Check project in the Southern Region, work continued to have tensiometers adopted for irrigation scheduling. Tensiometers were found to be particularly useful in drip irrigation. A major part of the third year was spent in advising drip irrigators of best irrigation practices. There are approximately 130 growers in the Bundaberg/Isis area using drip.

EnviroSCAN soil moisture monitoring equipment was used on three properties to demonstrate soil water movement with drip irrigation, in particular deep drainage loss.

Three trials were established on furrow irrigated properties that had been considered by the Department of Natural Resources to be most at risk from deep drainage losses from furrow irrigation. The trials were monitored with a neutron moisture meter.

2.3 Other districts

Action learning based around grower groups was used on the Atherton Tablelands and in the Herbert and Sarina districts to encourage growers to improve their water use efficiencies. Water Check relied on local BSES extension staff to organise the grower groups in these districts and to follow up any grower inquiries. However, the project staff were involved in the running of the shed-meetings. The shed-meetings were tailored to each district based on local knowledge.

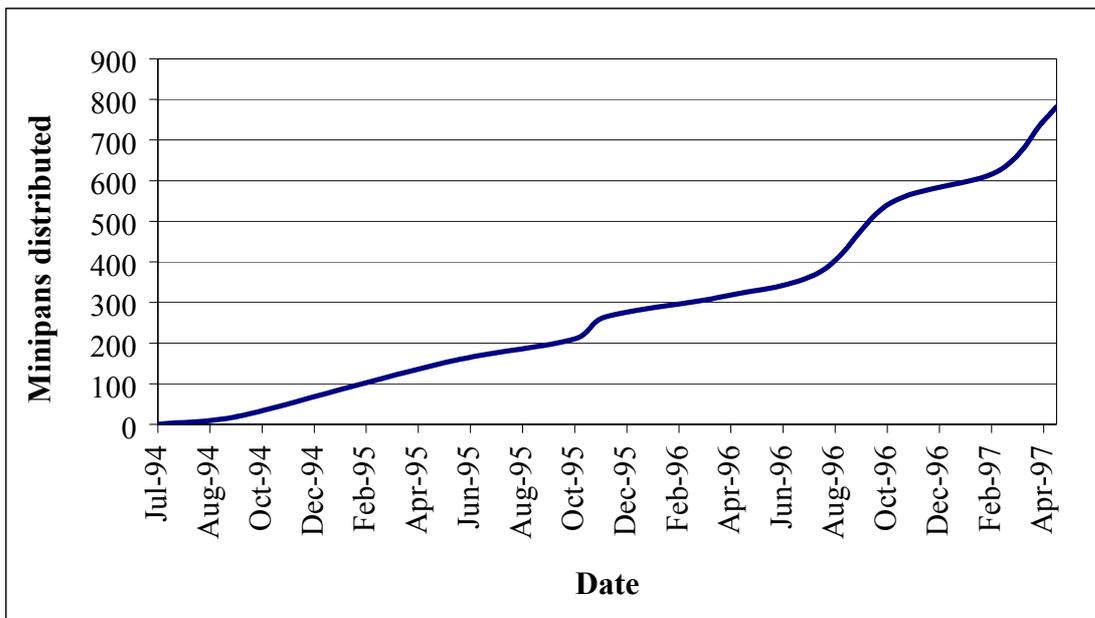
3.0 RESULTS

3.1 Burdekin

3.1.1 Irrigation scheduling

Over the three-year life of the 'Water Check' project over 500 minipans were distributed to Burdekin canegrowers. Figure 1 shows the cumulative distribution of minipans to the whole industry. It can be seen that nearly 800 minipans were given out statewide.

Figure 1 Cumulative distribution of minipans in the Australian Sugar Industry during the life of the 'Water Check' project



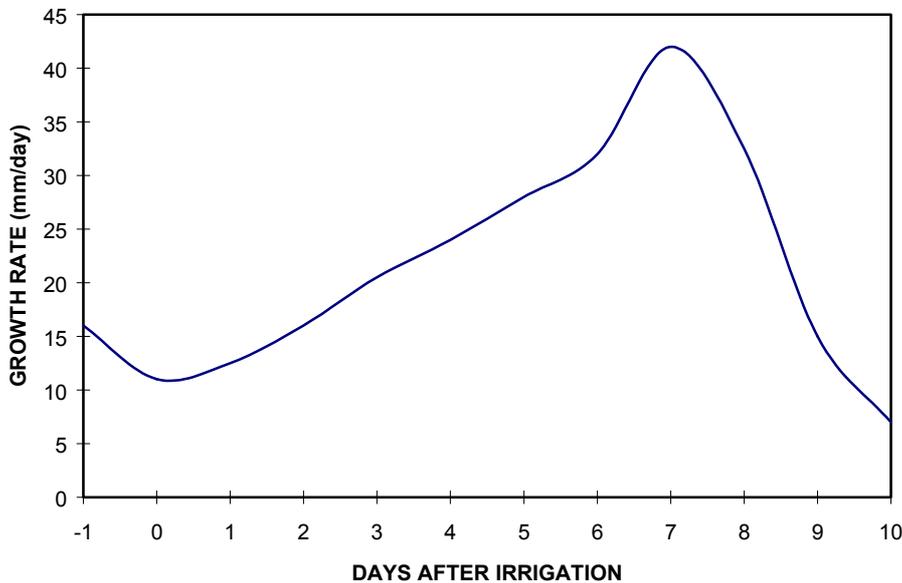
In the Burdekin over 200 minipans were calibrated by growers for soil type. It was found that there were marked differences in maximum growth rates between the main Burdekin varieties (Table 1).

Table 1 Maximum daily growth rates recorded for the major Burdekin sugarcane cultivars

<i>Cultivar</i>	<i>Maximum daily growth rate (mm)</i>
Q96	44
Q117	35
Q124	50
Q127	45

An example of a minipan calibration is shown in Figure 2. The maximum growth rate in this case was 42 mm/day, which occurred 7 days after irrigation. The crop reached 50 % of the maximum growth rate (21 mm/day) just under two days later. At this point 90 mm had evaporated from the minipan.

Figure 2 Typical crop growth rates after irrigation of an early plant Q96 crop



The crop growth calibrations conducted by the growers allowed us to group the major soil types in the Burdekin according to their irrigation deficits (Table 2).

It was found that the minipan evaporated 15% more water per day on average than the 'Class A pan' through the summers of 1995/96 and 1996/97 (Figure 3). If a crop factor of 0.85 is used for an actively growing fully canopied crop, it is possible to estimate readily available water (based on 50% of maximum growth rate) for the main Burdekin soil types (Table 2).

For example, if a minipan has been calibrated on a cracking clay soil to an irrigation deficit of 120mm, 102mm would have evaporated from a 'Class A' pan over the same time frame. To convert this to crop water use (or readily available water in this case), a crop factor of 0.85 is used on the 102mm which was evaporated from the 'Class A' pan. Therefore the estimated readily available water for that particular cracking clay was 90mm.

Figure 3 Daily minipan evaporation in the Burdekin as a function of daily 'Class A' pan evaporation from December to March, 1995/96 and 1996/97

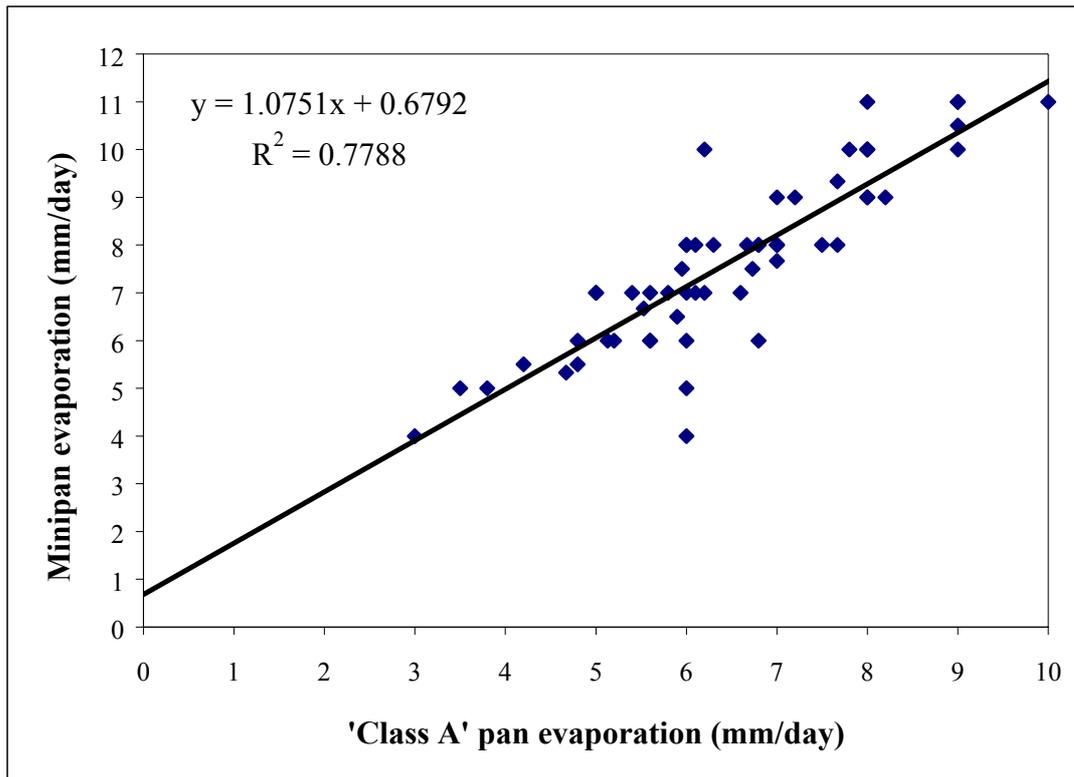


Table 2 Minipan deficits and estimated readily available moisture contents for the major Burdekin soil types

Soil type	Minipan deficit (mm)	Estimated readily available water (mm)
Cracking clay	110 – 120	85 – 90
Non sodic duplex	80 – 90	60 – 65
Sodic duplex	60 – 110	45 – 85
Delta alluvial	50 – 110	35 – 85

In three comparisons between 1993 and 1994 ratoon crops, the adoption of irrigation scheduling using evaporation mini-pans lifted the cane yields by 10-25% of that recorded for the previously harvested ratoon crop (Table 3). This is not normally the case; yields usually decline with increasing crop age.

Table 3 Yield response to irrigation scheduling using evaporation minipans in the Burdekin

Soil	Variety	Non Scheduled 1993 (t/ha)	Scheduled 1994 (t/ha)	Production Increase (%)
Clay loam over sand	Q117	124 (1R) [†]	136 (2R)	10
Sandy loam	Q117	107 (1R)	120 (2R)	12
Sandy loam over sodic clay	Q96	88 (2R)	110 (3R)	25

[†] 1R = 1st ratoon, 2R = 2nd ratoon, and 3R = 3rd ratoon

During 1995, the cane yield response to varying evaporation mini-pan deficits was demonstrated by encouraging a canegrower to split his paddock based on different deficit figures (Table 3). It was shown through the calibration procedure that a mini-pan deficit of 120 mm was appropriate. However, due to shortages of irrigation supplies at peak periods, the irrigation was often delayed until the minipan had reached 150mm.

Table 4 Effect of minipan deficits on cane yields on a cracking clay soil in the Burdekin

Minipan Deficit (mm)	Cane Yield (t/ha)	Commercial Cane Sugar (%)	Sugar Yield (t/ha)
120	132.9	15.6	20.73
150	104.2	15.6	16.26

This demonstration had considerable credibility with Burdekin River Irrigation Area (BRIA) canegrowers. It not only emphasised the magnitude of the yield differences produced by following different evaporation mini-pan schedules, but more importantly, the data were collected with the participation of a canegrower widely recognised by his peers as being a 'top' farmer.

A trial was established in March 1997 to compare irrigation scheduling with the minipan against visual scheduling by a canegrower late in the season (Table 5). The grower used approximately 2 ML/ha (2 irrigations) less than the minipan scheduled treatment between early March and the end of May. However productivity increased by over 2 tonnes of sugar/ha in the minipan treatment. The trial showed that there was a clear advantage to irrigation scheduling with the minipan late in the season compared with scheduling on experience. It also showed that the minipan was useful until the end of May in that year.

Table 5 Yield response to irrigation scheduling using evaporation minipans compared with visual scheduling in the Burdekin (March to May, 1997)

Scheduling method	Total cane (tonnes)	Area of treatment (ha)	Tonnes cane/ha	CCS	Tonnes sugar/ha
Minipan	116.48	0.699	166.64	16.40	27.33
Visual	380.25	2.377	160.00	15.66	25.06

Productivity data from the 1995 and 1996 harvest seasons in the Burdekin demonstrated that minipans were improving water use efficiencies. In Table 6, the sugar yield of 79 Burdekin growers improved between the 1995 and 1996 seasons, despite the average sugar yield over the entire Burdekin declining by 1.5%. In real terms, this improvement in yield is worth in excess of \$10 million in the value of extra sugar alone, if applied to the Burdekin as a whole.

Table 6 The effect of scheduling irrigations with minipans on sugar yield of 79 Burdekin farms

	Sugar Yield/ha	Value \$/ha	Extra \$ per 70 ha farm	Extra tonnes/sugar in Burdekin	Extra \$ in Burdekin
1995 (no mini-pans)	16.63	\$4,989			
1996 (with mini-pans)	16.91	\$5,073			
Difference	+0.28	+\$83	\$5,806	16,907	\$5,072,000
Adjusted difference	+0.53	+\$159	\$11,130	34,125	\$10,237,500

The adjusted difference is based on an actual 1.5 % sugar yield per ha decrease in the Burdekin between the 1995 and 1996 seasons. Sugar price assumed to be \$300/tonne. Extra tonnes and values calculated on 60,383 ha and 64,387 ha of sugarcane harvested in the Burdekin in the 1995 and 1996 seasons respectively.

In the 1996 season, many of the growers used in the Table 6 assessment were not using the minipans for the complete season or over their entire farms. For this reason, another 37 growers' productivity data who began using minipans in 1995 and continued to use them in 1996 was analysed (Table 7). This gave a better estimation of the impact of the minipan in the Burdekin.

Table 7 The effect of scheduling irrigations on sugar yield of 37 Invicta farms using minipans for two seasons

	Sugar Yield/ha	Value \$/ha	Extra \$ per 70 ha farm	Extra tonnes/sugar in Burdekin	Extra \$ in Burdekin
1995 1 st year with pan	16.45	\$4,935			
1996 2 nd year with pan	17.20	\$5,160			
Difference	+0.76	+\$228	\$15,960	48,934	\$14,680,200
Adjusted difference	+1.00	+\$300	\$21,000	64,387	\$19,316,100

The adjusted difference is based on an actual 1.5 % sugar yield per ha decrease in the Burdekin between the 1995 and 1996 seasons. Sugar price assumed to be \$300/tonne. Extra tonnes and values calculated on 60,383 ha and 64,387 ha of sugarcane harvested in the Burdekin in the 1995 and 1996 seasons respectively.

Table 7 shows that the increase in sugar yield over the 37 farms was greater between 1995 and 1996 than in Table 1. Indeed the adjusted difference (because of the sugar yield decrease over the Burdekin between 1995 and 1996) was worth to a grower with 70 ha (the average size farm in the Burdekin), approximately \$21,000 extra revenue. Over the entire Burdekin, the extra revenue generated from the use of minipans would be nearly \$20 million.

From a survey of the growers in Table 7, it was found that on average no extra water was used in the 1996 season compared with the 1995 season to produce the extra yield. Therefore, an increase in water use efficiency for the growers was realised. This amounted to 0.5 tonnes of cane extra per ML of total water applied (an improvement from 7.8 to 8.3 tonnes/ML).

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

Minipans have been widely adopted as an irrigation scheduling tool in the Burdekin. BSES extension staff in the Burdekin conducted two grower surveys over the 1994/95 and 1996/97 seasons (Table 8). Approximately 40 growers were surveyed each time. Adoption of minipans has increased over the two years by 38% over the whole Burdekin. It is very encouraging to see the adoption rate of minipans by Burdekin Delta growers. Evaporation minipans have also been promoted for scheduling furrow irrigations in Bundaberg, the Central district (particularly Proserpine and Mackay), and in the Mareeba district of the Atherton Tablelands.

3.1.2 Irrigation efficiencies

In conjunction with the LWRRDC funded project, 'Increasing Irrigation Efficiencies in the Australian Sugar Industry' Burdekin Delta growers collected their own water use data in the 1995/96 (13 sites) and the 1996/97 season (8 sites). The average irrigation efficiencies for both seasons are shown in Table 9.

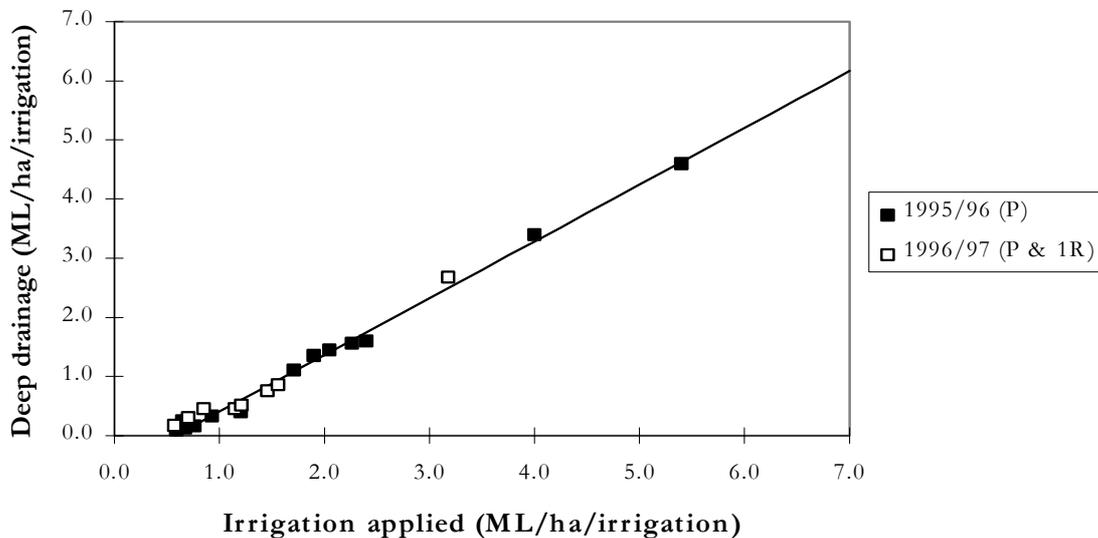
Table 9 Water use data for field sites in the Burdekin Delta in the 1995/96 and 1996/97 seasons

	Average volume applied (ML/ha/irrigation)	Deep drainage losses (ML/ha/irrigation)	Irrigation application efficiency (%)
Plant 1995/96 (13 sites)	1.86	1.26	40
Plant 1996/97 (4 sites)	1.66	1.16	43
1 st ratoon 1996/97 (4 sites)	1.05	0.50	57

Assumes 0.1 ML/ha/irrigation tail-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 4).

Figure 4 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.

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 4, is thought to be an overestimate of the average tailwater loss in the Delta.

An example of the grower trials conducted in conjunction with the project ‘Increasing Irrigation Efficiencies in the Australian Sugar Industry’ is shown in Table 10. The on-farm grower trials showed that it was possible to substantially reduce water usage with either reduced tillage practices or by changing furrow shape from a broad-based ‘U’ to a narrow ‘V’ shape, without affecting crop yield. In the trial in Table 10, water usage was reduced with these treatments by 40%. A combination of reduced tillage and ‘V’ shaped furrow reduced water usage by 60% without affecting yield (for more information on the on-farm furrow shape and tillage trials, see BSES Project Report PR97006, ‘Increasing Irrigation Efficiencies in the Australian Sugar Industry’).

Table 10 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)	
	Broad U	Narrow V	Broad U	Narrow V
Total before hill-up	5.18		10.74	
Furrow Shape	Broad U	Narrow V	Broad U	Narrow V
Total (8 irrigations) ML/ha/irrigation	15.74 1.97	10.56 1.32	25.46 3.18	17.55 2.19

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.

Delta growers have taken to ‘V’ shaped furrows exceptionally well. Feedback from the grower groups highlighted the high adoption rate. This was confirmed by a grower survey, which showed that 52% of Delta growers had changed their furrow shapes. It was thought that this could save on average 5 ML/ha/season over half of the Delta region. The high adoption of this practice is primarily a result of the action-learning technique used in ‘Water Check’ and ‘Increasing irrigation efficiencies in the Australian Sugar Industry’ (Holden and Mallon, 1997).

Reducing tillage was not as popular, with 24% of Delta growers surveyed adopting this management practice. The use of residual herbicides is a relatively new concept for Burdekin Delta growers; therefore they may be some hesitancy in their use. The high price of many of the residual herbicides may also deter their use to some extent. It is also arguable from an environmental standpoint whether we should be recommending the increased use of herbicides to reduce deep drainage losses on freely draining alluvial soils.

3.2 Bundaberg

3.2.1 1994/95

The volumes of readily available soil water (RAW) for the main Bundaberg cane growing soils are shown in Table 11.

Table 11 Storage of readily available water (RAW) in Bundaberg soils

Soil type	Texture	RAW in the root zone (mm)
Alluvial	Clay loam	90
Red volcanic	Clay loam	90
Humic gley	Silty clay loam	70
Red earth	Sandy loam	60
Red podzolic	Sandy loam	60
Yellow podzolic	Fine sandy loam	60-70
	Sandy loam	40-50
Gleyed podzolic	Fine sandy loam	60-70
	Sandy loam	40-50
Black earth	Medium clay	50-60
Alluvial	Sand	40

The majority of these soils fit in the expected soil water range, with the exception of the Black earths, which hold considerably less than anticipated. The RAW of the Black earth appears to be limited due to the topsoil being only 40cm over a basalt 'C' horizon. The soil water information (Table 11) has been disseminated to growers through small grower groups. In some cases some further testing of the RAW figures was necessary to gain grower confidence in the data.

Results from the monitoring of irrigation application efficiencies of furrow, overhead and drip irrigation systems suggested a wide range of efficiencies, especially for furrow and drip systems (Table 12).

Table 12 Irrigation applications efficiencies from Bundaberg (1995)

	Irrigation system		
	Winch	Furrow	Trickle
No. of sites	8	3	5
Irrigation efficiency (range)	70-85%	10-90%	30-90%
Soil types	Various	Red volcanic Gleyed podzolic	Gleyed podzolic Sand Red volcanic

Poor application efficiencies with drip irrigation were found to be the result of excessively long irrigations. In one instance, 30% efficiency was the result of a 24-hour irrigation on sandy soil where the lateral wetting pattern was limited to 25-30% of the soil profile.

Furrow efficiencies were shown to be very low where large volumes (up to 7 ML/ha) of irrigation water was applied to highly permeable soils. The majority of the applied water infiltrated past the root zone and was lost to deep drainage.

These data support the view that irrigation systems are not inherently efficient per se and efficiencies depend largely on management of the particular system.

Eleven grower groups were held in the first year of the project in Bundaberg/Isis/Maryborough to make growers aware of Water Check, to begin the grower participation and to start the dissemination of the project's results.

During the 1994/95 season, it was discovered that tensiometers were more suitable than minipans for scheduling overhead and trickle irrigations. This was because growers were uncertain how much water to put in the pan after irrigation, as their overhead irrigations were not filling up the soil profile as happens with furrow irrigation. Also with limited water or infrastructure, most of the growers were not able to maintain the irrigation schedule that the minipan was suggesting.

3.2.2 1995/96

Late-season irrigation trial

Some growers opted not to water some of their cane due to the water restrictions in the Bundaberg district in the second year of the Water Check project. This allowed project staff to establish a late irrigation trial on a grower's property. Regular rainfall up to the end of January had maintained the crop in a reasonable condition, but by the end of March, it was severely stressed. At this point the following furrow irrigation treatments were established on the block:

1. No irrigation
2. One irrigation of 1ML/ha
3. Two irrigations of 1ML/ha each

Table 13 Height, CCS and yield response to late irrigations in Bundaberg (1995/96)

Treatment	Average height of cane (cm)	CCS	Yield (TC/ha)
No irrigation	162	14.09	38.80
One irrigation	194	15.00	50.74
Two irrigations	208	15.23	54.63

Treatments applied between March and May. Soil type was a brown volcanic.

Over 200 mm of rainfall was received at the site in early May.

The late irrigation demonstrated that the value of irrigation is not limited to the hotter months of the year but good water use efficiencies can be achieved later in the season. This agrees with a similar trial conducted late in the season in the Burdekin (Table 5).

The response in tonnes of cane per ML for just the late irrigation was:

- | | |
|--------------------|---------|
| 1. No irrigation | 0 t/ML |
| 2. One irrigation | 12 t/ML |
| 3. Two irrigations | 8 t/ML |

This information is useful when irrigation supply is supplemented later in the year from river flows.

Alternate drip irrigation compared with every-row drip irrigation

In Bundaberg several growers were reusing drip irrigation tape used in small crops on the surface of their canefields. In most cases, the tape was laid down the centre of the interspace. To reduce the labour requirement, some growers opted only to run tape down every second interspace.

A trial was established in March 1996 to compare the two systems. The treatments were irrigated as required with a tensiometers installed next to the tape, in the row and in the interspace without tape (in the treatment of drip tape down every other interspace). It was found that the most reliable tensiometers to use for irrigation scheduling were those in the row because the tensiometers in the interspace without tape lost their suction due to dry conditions.

Average growth rate from March to May 1996

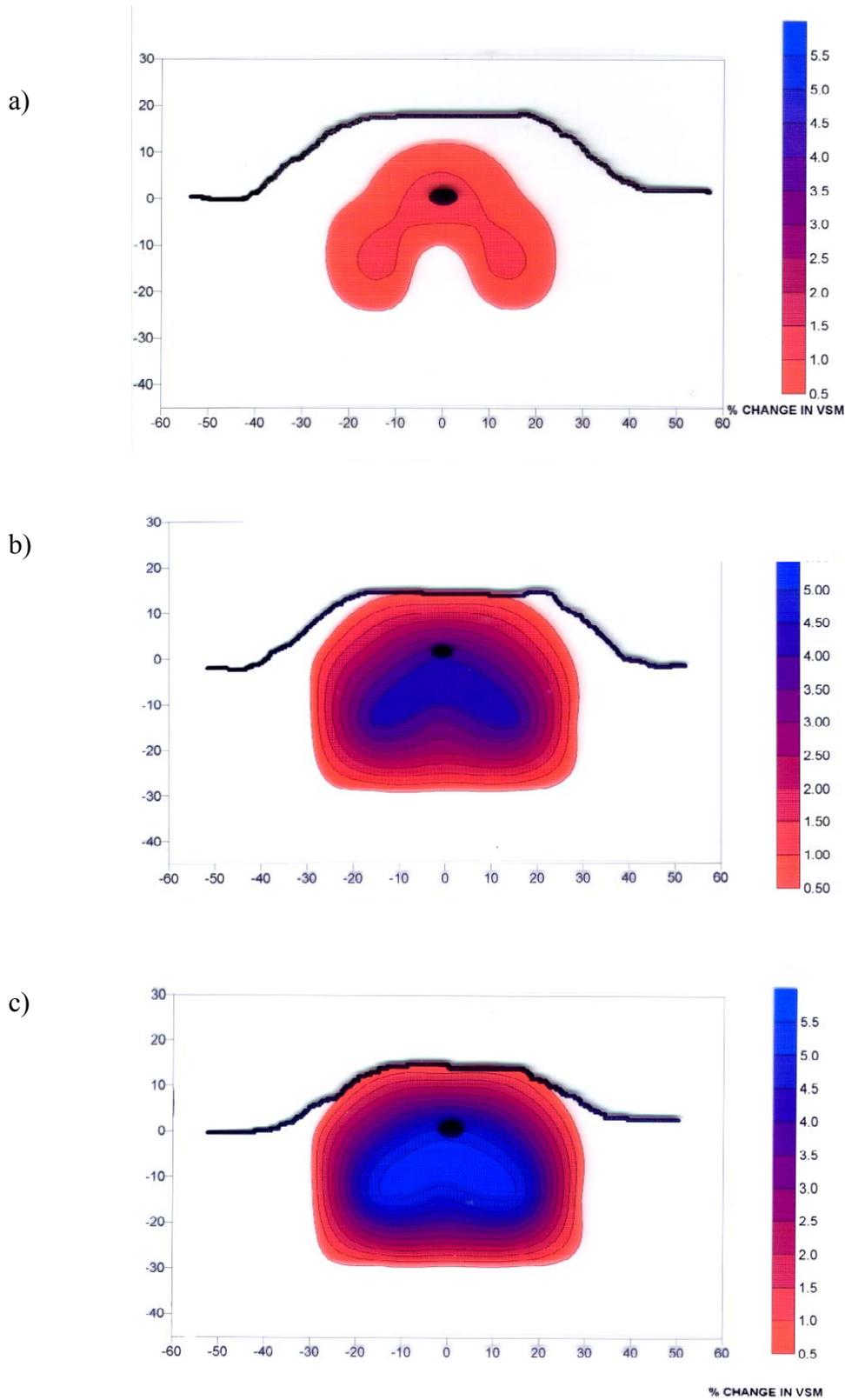
Every interspace	11.75 mm/day
Every second interspace	10.60 mm/day

This preliminary trial indicated that with the correct irrigation scheduling, cane yield may not be reduced by using surface drip tape in every second interspace. However, it is recommended that the trial be repeated through the whole irrigation season.

Drip irrigation wetting pattern trials using the TDR

Figure 5 demonstrates the water movement and moisture content around drip tape irrigating a kraznozom soil. It can be seen that the water moves laterally first and then downwards. After 90 minutes, the maximum wetted area is reached. Continuing irrigation for 180 minutes does not increase the size of the wetted volume but increases its moisture content.

Figure 5 Drip irrigation wetting patterns on a kraznozem soil: (a) 30, (b) 90 and (c) 180 minutes after the start of irrigation (VSM refers to volumetric soil moisture)



If irrigation is continues longer than 180 minutes on this soil type, water will probably be lost past the root zone.

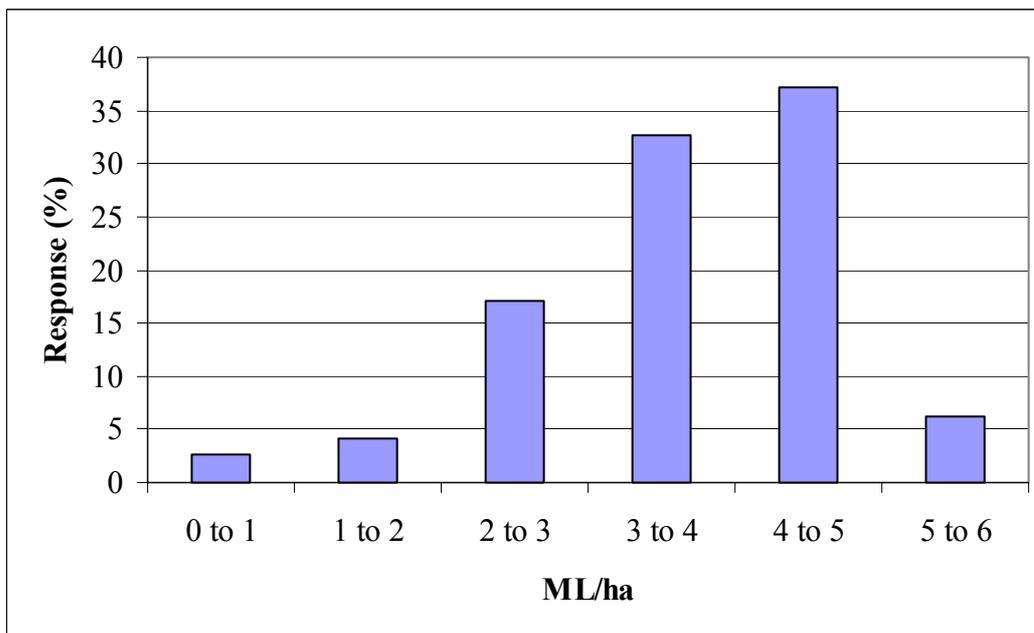
Drip irrigator groups were formed in each mill area. Irrigation shed meetings were run with approximately 40% of growers attending.

Bundaberg irrigation survey summary

It was found that the major soil type from the surveyed growers was yellow podzolic (27% of area) with lesser amounts of krasnozem (22%) and red earth (17%). Growers responded that the lighter textured soils (ie. yellow podzolic) needed more frequent irrigations but generally received the same amount of water at each irrigation. The reason for this was because the growers were not adjusting the rate of application on their water winches.

The growers were asked about their water allocation. Figure 6 demonstrates the wide variation in water allocation in the Bundaberg district. While 37% of growers had an allocation between 4 and 5 ML/ha, more than half of the growers questioned had less than 4 ML/ha. The average allocation based on the gross assigned area was 3.6 ML/ha.

Figure 6 Bundaberg water allocation (from a survey of 70 growers)



Irrigation frequency on the farm affected crop growth and profitability. On average it took more than 15 days to irrigate a farm. More than 30% of the growers surveyed took more than 15 days to complete an irrigation cycle. This was determined by the availability of irrigation equipment and water. Most growers stated that they would not consider expenditure on addition irrigation infrastructure unless there was an increase in the availability of water.

Most growers were matching the application rates of their irrigations to the water holding capacity of their soils. In particular, water winches were applying less water than the soils' capacities. Excessive applications are probably restricted to furrow irrigation of the kraznozem, red earth and podzolic soils.

The predominant irrigation system in Bundaberg is the water winch (73% of the irrigated area). Approximately 21% of the district is furrow irrigated and 6% is drip irrigated.

As part of the survey, growers were asked to rank the different systems for irrigation efficiency. More than 89% of the growers surveyed responded that drip irrigation was the most water efficient. Water winch irrigation was ranked second by 75% of growers and over 85% of growers thought that furrow irrigation was the least water efficient system.

Data collected from this project (Table 12) has shown that all irrigation systems have the potential to be either very efficient or inefficient depending on the management of that system. This is especially the case with furrow and drip irrigation. Because water winch irrigation does not generally apply more water than the soil can hold, the irrigation losses are generally through evaporation or off-site losses on windy days.

3.2.3 1996/97

An example of irrigation scheduling with tensiometers is shown in Figure 7.

In the case in Figure 7, the grower was only irrigating once every ten days for a period of 24 hours on a sandy soil. After consultation with Water Check staff, the grower was advised to irrigate when the tensiometer at 30 cm reached 30 centibars (cb) (Figure 7). This change in practice reduced deep drainage loss and provided water more in line with crop requirements.

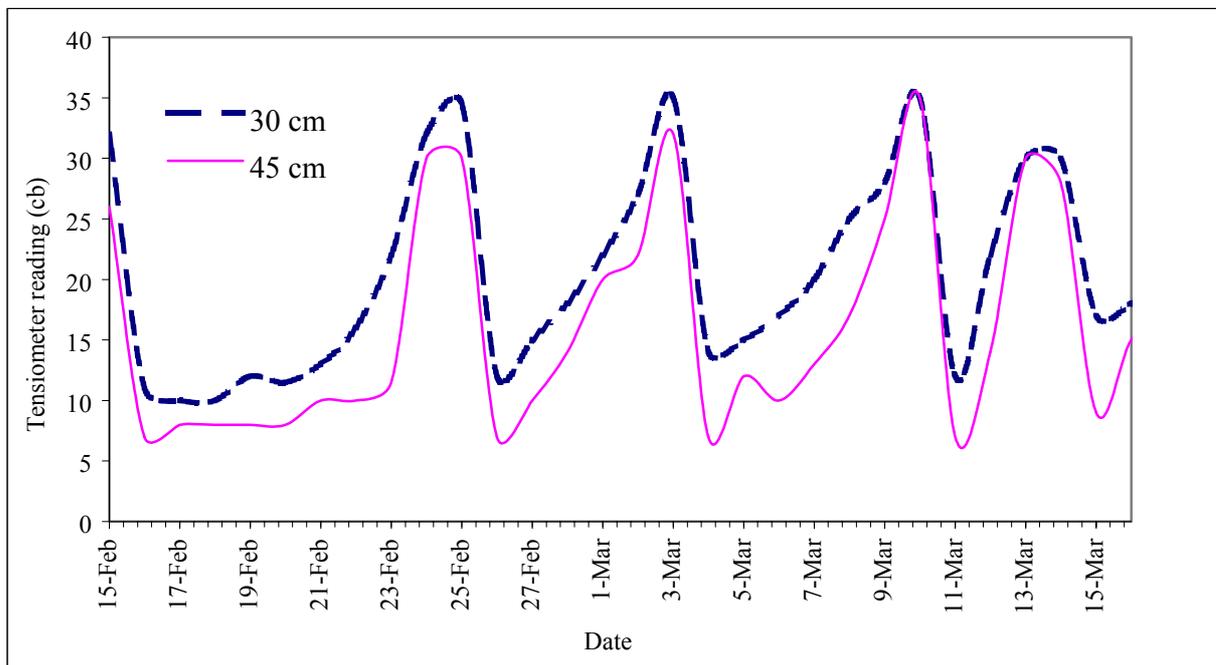


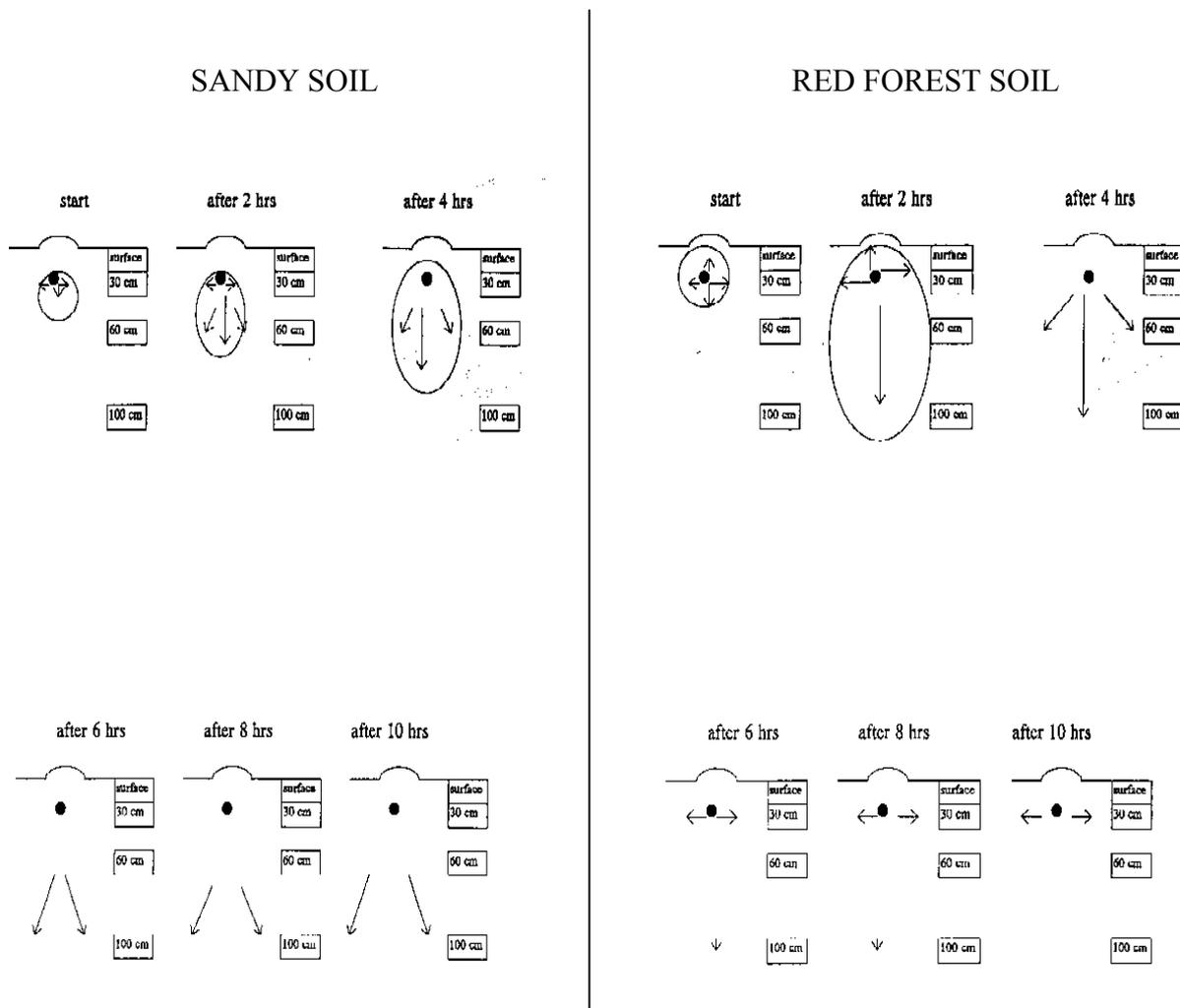
Figure 7 Scheduling of drip irrigation using tensiometers

Figure 8 is a summary of the irrigation water movement from a three hour drip irrigation from a sandy soil and a red forest soil in the Bundaberg area using an EnviroSCAN soil moisture monitor. The system had three tubes that were: beside the drip tape next to the emitter, 20 cm away from the emitter and between emitters 20 cm away from the tape. Each tube had sensors at 10, 30, 60 and 100 cm below the soil surface.

Figure 8 shows that on sandy soils, drip irrigation for three hours caused considerable deep drainage up to ten hours after the start of the irrigation. This leads to poor irrigation efficiencies and considerable risk of nutrient loss. It was recommended to the grower that he irrigate for no longer than 90 minutes at a time to reduce the deep drainage loss. It was calculated that this irrigation regime would lead to water savings of 50% for the whole season.

Figure 8

MOVEMENT OF IRRIGATION WATER FROM A 3 HOUR IRRIGATION EVENT



On the red forest soil (Figure 8) water reached 100 cm two hours after the irrigation commenced. Deep drainage was present but at a lower level than the sandy soil. The lateral movement of water was also much greater and lasted for much longer in the red forest soil. Again it was recommended that irrigation times were reduced to reduce water losses to both deep drainage and lateral movement of water into the interspace.

The overall conclusion to the drip irrigation wetting pattern work conducted in the Water Check project was that all the soils showed the same behaviour in the wetting-up phase (Figures 5 and 8). Firstly water moves out laterally to its fullest extent in the first part of the irrigation and then water moves deeper. The time taken for the wetting front to reach the bottom of the root zone is dependent on the water holding capacity of the soil but ranges from two to six hours of irrigation. If the irrigation is continued for longer, the wetted width is not increased and water is lost to deep drainage. Optimum drip irrigation times for the main Bundaberg soil types were included in the Bundaberg irrigation guide produced by Water Check staff.

Three monitoring sites were established to measure deep drainage losses from furrow irrigation on soils that the Department of Natural Resources had deemed to be unsuitable for furrow irrigation. Moisture was monitored with the use of a neutron probe and irrigation amounts were determined by water meter readings.

The irrigation practices from the three farms investigated varied considerably.

One site with freely draining soil (Oakwood soil) showed the benefit of shorter irrigation runs and frequent irrigation. Two cups were used per furrow and irrigation time was no more than two hours. Tailwater was collected and re-used. There was no measurable drainage at this site.

The second site had the problem of surface sealing and low infiltration (Kepnock soil). After two green harvests there was enough trash on the ground to slow water flow down the furrow and increase time for infiltration. From neutron probe measurement it was found that the top of the field had deep drainage of 80mm per irrigation. However, the bottom of the field was not receiving enough water because the grower was shutting-off irrigation before the water reached the end of the furrows. The recommendation was to reduce the number of furrows being irrigated from 60 to 30 to increase inflow rate per furrow. This would reduce the opportunity time for deep drainage loss at the top end of the field.

The third site was also a freely draining Oakwood soil. A 'V' shaped furrow and high inflow rates were used on this property. As a result the neutron probe showed that there was no measurable deep drainage loss. Other growers in the area on the same soils have found excessive drainage to be a problem. The adoption of the correct furrow shape and inflow rate would reduce this problem significantly.

The outcome of the three trials was that correct management of the furrow irrigation system would minimise groundwater contribution. In these cases, if the growers were using furrow irrigation within reasonable limits, the factor affecting efficiency and drainage would be management rather than soil type.

3.3 Other districts

3.3.1 Atherton Tablelands

The Water Check project concentrated on the Mareeba/Dimbulah Irrigation Area (MDIA). Furrow irrigation is the most popular system (> 80%), followed by low-pressure overhead irrigation. For this reason, evaporation minipans were promoted at a discussion night that was held in the Mareeba area in September 1994. Over two-thirds of Mossman growers who had assignment on the Tablelands attended the meeting.

A number of minipan calibrations were conducted in the Mareeba district over the course of the Water Check project. Maximum growth rates were recorded for the main varieties (Table 14). Approximately 100 minipans have been distributed in the Mareeba district since the start of the Water Check project.

Table 14 Maximum growth rates recorded for the main Mareeba sugarcane varieties

Variety	Maximum growth rate recorded (mm/day)
Q124	48
Q120	32
Q96	43

Irrigation data collected by the BSES extension officer (Drewe Burgess) for the Atherton Tablelands demonstrated that there was considerable room for improvement in water use efficiencies of furrow irrigators (Table 15). The data suggest that low-pressure overhead or drip irrigation systems are inherently more efficient. Irrigation efficiency data collected by Water Check staff in Bundaberg refutes this (ref. 3.2.1 this report). Often it is the management of the irrigation system that has more bearing on irrigation efficiencies than the system itself. However, furrow irrigation is less suitable than overhead or drip on many of the freely draining soils of the MDIA, even with the best practices described in this report.

Table 15 Irrigation statistics for the 1995 Mareeba/Dimbulah sugarcane crop

Locality	Irrigation method	Number of irrigations	Irrigation applied (ML/ha)	Water use efficiency (tonnes of cane/ML)
Walkermin/Mareeba	Pivot/Lateral	4	6.3	10.1
Biboohra	Furrow	3	11	6.9
Arriga	Furrow	10	12	7.0
Emerald Creek	Drip	1	5.5	11.8

Two further shed meetings were held in the Mareeba area in October 1996.

3.3.2 Herbert

Irrigation in the Herbert is mainly confined to the Stony Creek and Bamberoo sub-districts. In most years growers use less than 2 ML/ha applied to young plant cane between August and December.

Two shed meetings were held in August 1994 in Ingham to give growers a better understanding of the water holding capacities of their soils and the amounts of irrigation water they should be applying. Two measurement sites were established and an irrigation response trial was established on a local grower's property by BSES extension staff in the Herbert.

In October 1996, two further shed meetings were held in the Herbert, to discuss irrigation efficiencies and scheduling overhead irrigation systems with tensiometers. The results from the irrigation response trial were also discussed (Table 16).

Table 16 Response to irrigation at Yuruga (Herbert)

Treatment	Irrigation applied (mm)	Tonnes of cane/ha	CCS	Tonnes of sugar/ha
Irrigated	214	127	13.52	17.2
Raingrown	43*	112	14.72	16.5

* one irrigation to establish crop

The trial was repeated in the 1996/97 season. Unfortunately there were no differences in irrigation applied between treatments because of a wet season. This highlights the wide variation in water requirements and irrigation response between seasons in the Herbert.

3.3.3 Sarina

A shed meeting was held in Sarina in September 1995 to raise awareness of the benefits of irrigation as many growers in the Dawlish district were under-utilising their irrigation supply. Many of the growers were not using their water through the peak growth period of November to February, and were conserving it for later in the season. The growers were encouraged to use their water earlier when the crop required it. The Dawlish district had the highest productivity of the Sarina District in the 1996 harvest. In the previous year, Dawlish achieved only average productivity.

The appropriate timing and quantities of irrigations were also discussed. Growers were introduced to irrigation scheduling and were shown how to calibrate tensiometers to crop growth rate.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 Irrigation scheduling

The adoption of minipans for furrow irrigation scheduling is one of the highlights of the Water Check project. The evidence of the success of the minipan is in the large distribution of minipans both in the Burdekin and elsewhere in the irrigated sector of the industry (Figure 1). The high rate of adoption in the Burdekin (62 %) has been confirmed by the irrigation surveys conducted in 1994/95 and 1996/7 (Table 8).

The success in the adoption of the minipan where other irrigation scheduling tools have failed can be attributed to a number of factors. Firstly the minipan is a very simple tool that is easy to understand and use. Provided that the growers fill up the minipan after irrigation, there is really nothing that can go wrong or break down. It also provided growers with a picture of the moisture within their soils. The calibration procedure ensured that the minipan was relatively accurate for the particular circumstances on a grower's property. Having the growers complete the calibration themselves gave the procedure and the minipan immediate acceptance in most cases.

Burdekin River Irrigation Area (BRIA) growers were quicker to adopt the minipan compared with their Delta counterparts. The reasons for this were:

- A higher proportion of BRIA growers were new to canegrowing and had no preconceived ideas about irrigation management.
- Many Delta growers felt that they could not keep up with the minipan, especially if they were having problems getting water through to the end of the field (because of deep drainage). In many cases this situation was remedied to a greater extent by having the growers try 'V' shaped furrows and then using minipans.
- BRIA growers tended to have higher water delivery capacities and were able to complete irrigation cycles much quicker than Delta growers.
- Most BRIA farms have a higher water holding capacity compared to the predominantly alluvial Delta farms and need irrigation less frequently.

Nevertheless the adoption of minipans on Delta farms increased significantly over the final two years of the project. By June 1997, nearly 50% of Delta growers were using minipans for scheduling irrigations (Table 8).

The project highlighted the following opportunities for further research with the minipan as a scheduling tool:

- The minipan was not as suitable for scheduling overhead or drip irrigation systems as tensiometers. The reasons for this have been described in 3.2.1.
- Minipans are only being recommended for irrigation scheduling for crops with a fully closed in canopy up to the point of crop maturity. For most crops this is between the months of November and May. This covers the main irrigation season in most districts, but still leaves a large proportion of the year to scheduling irrigations based on experience or visual signs of moisture stress. The minipan could be used for the whole life of the crop if the evaporation was adjusted with crop factors based on the percentage of canopy cover and a separate crop factor at the end of the season for a maturing crop. These crop factors (or crop coefficients) have been established for sugarcane. Even though the crop factors would enable the minipan to be used year round, they would complicate a very system that has succeeded in part because of its simplicity, particularly if a number of crop factors were used. The alternative is to use

a scheduling tool that does not rely on a relative factor such as evaporation to estimate crop water use particularly in the winter months, but measures actual soil moisture. Tensiometers would be a relatively inexpensive way of achieving this.

- The use of the 50% of maximum growth rate for the refill point for irrigation is an arbitrary figure that seems to relate to established figures of readily available water (Figure 3 and Table 2). While this irrigation deficit suits full irrigation districts such as the Burdekin and Mareeba, it is probably not achievable or desirable for growers with limited irrigation water to attempt to irrigate based on the 50% growth deficit with minipans or tensiometers. BSES extension staff in the Central district have been recommending that growers use 30% of maximum growth rates to schedule irrigations. We need to ascertain whether this figure is the optimum for growers with limited water. Unfortunately limited water covers a huge range of water availability and it may eventuate that we need a number of different deficits based on the amount of available irrigation water.

4.2 Irrigation efficiencies

In the Burdekin, furrow irrigation efficiency trials were mainly conducted on a range of soil types in the Delta area. Most of this work has been reported in the BSES publication 'Increasing Irrigation Efficiencies in the Australian Sugar Industry' (PR97006). However, some additional comments can be made. Figure 4 shows the wide variation in irrigation efficiencies and demonstrates that the main irrigation loss in the Burdekin Delta is from deep drainage. These data were collected on a wide range of soil types. Holden and Mallon (1997) suggested that the main reason for the variation in irrigation efficiency was grower management rather than soil type, drill length or water quality. It is likely that all these factors are having some direct effect on irrigation efficiencies, but it appears that different management practices have the overriding influence. These practices include furrow shape, number of cultivations (Table 10) and also inflow rate per furrow. Raine and Bakker (1996) suggested that reducing inflow rate on alluvial soils from 2.8 to 1.7 l/s increased irrigation application efficiencies (by 12%). Holden and Mallon (1997) implied that the opposite occurs on freely draining alluvial soils. They stated that application efficiencies were increased from 30% to over 60% where inflow rates were increased from 0.6 to 2.5 l/s. The discrepancy in the results needs to be further investigated.

Data collected in Bundaberg also suggested that irrigation efficiencies were largely dependent upon the management of the irrigation system rather than the system itself (Table 12). Much of the work in Bundaberg concentrated on overhead and drip irrigation systems. Once the readily available water storage for Bundaberg soils was established (Table 11), it was then a matter of ensuring that growers with overhead systems applied that amount of water (or less) at each irrigation event. It was also important to make growers aware of irrigation losses through evaporation and uneven water distribution on windy days.

Case studies of drip systems in Bundaberg showed that application efficiencies could vary from 30 to 90% (Table 12). This system has the potential to be the most efficient, particularly on freely draining soils. However, the Water Check project has shown that many growers are irrigating with drip in the same way as they were with their former system (eg. irrigating once a week for several hours). The drip irrigation patterns collected by Water Check staff in Bundaberg suggested that deep drainage loss was a problem on many soil types of the district (eg. Figure 8). In most cases growers were given recommendations to increase irrigation frequency and decrease irrigation amounts. The majority of growers establishing drip irrigation on their farms do not appear to be getting the correct irrigation scheduling advice at present. To achieve irrigation efficiencies of over 90%, a drip irrigation system requires a high level of management expertise. There is a clear need to increase the knowledge level of drip irrigation (especially irrigation scheduling) across the industry. This is a prerequisite to the success of drip irrigation in the Australian sugar industry.

4.3 Met objectives

All of the broad objectives of the project as outlined in section 1.1 have been met. In particular:

- By successfully having new technology adopted, we have indirectly determined the perceived limits to the adoption of more efficient irrigation practices. This successful adoption relies on just two factors:
 - i) A simple tool or technique that the majority of canegrowers can understand and implement.
 - ii) The ability for the growers to demonstrate to themselves through action learning that the tool or technique is beneficial on their own properties.
- Through the numerous grower groups, shed meetings, field days, demonstration sites and trials associated with Water Check, growers throughout Queensland have been made more aware of the benefits of more efficient water use and best irrigation practices have been demonstrated and promoted (see Appendix A).
- A technical package has been developed by updating the BSES/SRDC Irrigation of Sugarcane manual. More efficient irrigation techniques are described in the manual especially in a new chapter, viz. 'Increasing Irrigation Application Efficiencies of Sugarcane' and in the chapter 'Irrigation Scheduling of Sugarcane.' A comprehensive irrigation guide was also produced for the Bundaberg district by Water Check and other BSES staff. It included soil characteristics, readily available water, and recommended irrigation systems and irrigation management for the various soil types.

4.4 Successful outcomes

4.4.1 Increased water use efficiency

It was expected that the project would increase water use efficiency (WUE) by 1 tonne of cane/ML for canegrowers using irrigation (Section 1.4).

Over 800 minipans have been distributed statewide. These have been shown to increase WUE in the Burdekin by at least 0.5 tonnes/ML (Holden *et al*, 1997). There are more than 400 growers in the Burdekin and at least 100 growers in other districts using minipans.

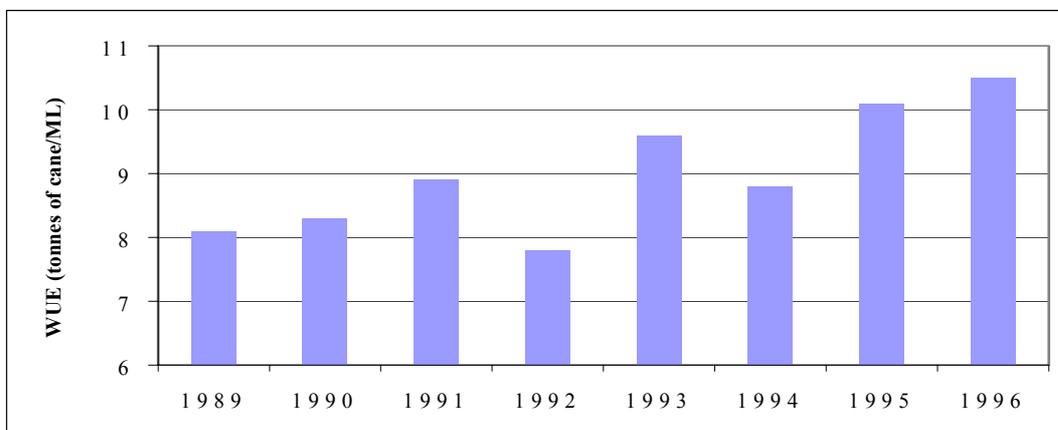
Approximately 270 growers (50 % of the Burdekin Delta) are trying V-shape furrows. The water savings from changing furrow shape are at best 15 ML/ha/season and at worst 2-3 ML/ha/season. Raine and Bakker (1996) in found a 50 % reduction in water use with

V-shape furrows. 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) for those growers.

In the Burdekin Delta 15% of growers have reduced tillage. Our trials showed water savings of between 7 and 10 ML/ha/season in plant crops. Raine and Bakker (1996) 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 for 80 Delta growers.

In Bundaberg, the WUE improved from 9.6 in 1993 (ie. before the start of the Water Check project) to 10.5 for the 1996 harvest (Figure 9). There are approximately 1000 growers in the Bundaberg district. If we assume that half of the growers achieved this increase, then 500 growers increased their WUE by 1.8 t/ML.

Figure 9 Water use efficiency of sugarcane grown in the Bundaberg district between 1989 and 1996



WUE - water use efficiency is tonnes of cane per ML of total water applied (irrigation and effective rainfall).

There are approximately 3000 growers in Queensland using some form of irrigation. Therefore the improvement in water use efficiency of 1.04 t/ML is over 45% of canegrowers using irrigation (Table 17). In all cases, the improvement in WUE is considered to be conservative. Table 17 also does not include any potential increases in WUE in the Central or Herbert districts. Therefore the Water Check project has met the desired outcome of an increase in WUE of 1 tonne of cane/ML over 25% of Australian canegrowers using irrigation.

Table 17 Summary of improvements in water use efficiency by the Water Check project

District	Reason for improvement in WUE	Estimated number of growers	WUE improvement (tonnes of cane/ML)
Burdekin	Minipans	400	0.5
	V furrows	270	0.9
	Reduced tillage	80	0.2
Various	Minipans	100	0.5
Bundaberg	General Water Check	500	1.8
Queensland		1350 (total)	1.04*

* Weighted average

4.4.2 More sustainable irrigated cane production

The Water Check project has encouraged growers to be more efficient with their irrigation water and has succeeded by increasing water use efficiencies. This will increase the sustainability of the water resource, which is already limited in many districts. At the conclusion of Water Check, around 60% of Australian sugar production was produced from irrigated land (Ridge, pers. com.). The more efficient use of the available water will assist in the sustainability of this production.

The better matching of irrigation application to soil water holding capacities has also reduced the amount of off-farm irrigation loss and associated nutrient and pesticide in the irrigation water.

4.5 Conclusion

The Water Check project has met all of its objectives. The success has been dependant on two factors.

Firstly the project has had good research data to extend, much of which originated from BS90S (Increased productivity through better design of canefields). Simple extension tools such as the evaporation minipan helped growers to understand concepts including irrigation scheduling and crop response to irrigations.

Secondly, the use of on-farm grower participatory trials and demonstrations based around small cell groups has proved to be a very successful extension method.

It is recommended that future extension projects use this method to improve adoption of new technology. If possible projects should also have simple tools so that growers can visualise research concepts on their own farms.

5.0 ACKNOWLEDGMENTS

We thank the Sugar Research and Development Corporation and the Bureau of Sugar Experiment Stations for the funding of the project 'Increased Adoption of Efficient Sustainable Irrigation Practices by Australian Canegrowers'. We also thank the participating growers who made this project possible and made it a success. Thanks go also to BSES extension and research staff in the Bundaberg, Central, Burdekin, Herbert and Mareeba districts for their assistance with the project. Appreciation is also extended to previous project supervisors, Dr Graham Kingston and Mr Evan Shannon.

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APPENDIX 1

PROJECT OUTPUTS

1. Publications

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2. Field days

1995 BSES Field day	Burdekin & Bundaberg
1996 BSES Field day	Burdekin & Bundaberg
1997 FNQ Field day	Mareeba
1997 BSES Field days	Burdekin, Bundaberg & Herbert
1997 FNQ Field day	Mareeba

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

3. Shed meetings/grower groups

1994

Mareeba	September (1) December (1)
Ingham	August (1)

1995

Burdekin	January/February (7) September (1) October (2) November (4) December (6)
Bundaberg/Isis	February (6) April (3) November (3)
Sarina	September (1)

Shed meetings/grower groups cont...**1996**

Burdekin	February (1) April (2) May (4) June (1) July (1) November (12) October (2)
Bundaberg/Isis	February (6) November/December (11)
Ingham	October (2)
Mareeba	October (2)

1997

Burdekin	February (9)
Bundaberg	January (2)

(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)
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