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FINAL REPORT – SRDC PROJECT BS64S

MANAGEMENT STRATEGIES FOR DRIP IRRIGATION SYSTEMS IN SUGARCANE

by

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SD98011

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SUMMARY

Two drip irrigation trials were conducted on clay (krasnozem) and sandy loam (gley podzolic) soils to investigate the optimum positioning of drip irrigation tape for effective irrigation on contrasting soil types. Further trials were established on the gley podzolic soil to compare fertiliser application through tape with conventional application; to compare drip and furrow irrigation and to compare drip irrigation performance at different row spacings.

The trials comparing deep and shallow placement of drip tubing showed that both are satisfactory for the soil types tested. More frequent watering is necessary if deep tape placement is used on sandy soils and water use efficiency is likely to be less on both soil types if extra water is needed at crop establishment to wet up the soil profile. It is recommended that tape be placed at 100-150 mm below planting depth to minimise these problems.

Fertigation through the drip tape showed no difference in crop response compared to conventional solid fertiliser application at recommended nitrogen rates, and the 75% nitrogen rate applied through drip performed similarly to the 100% conventional rate. It was found that application through the drip system in splits throughout the season reduced ccs at the 100% nitrogen rate but there was no effect on ccs at the 75% rate.

The comparison between drip and furrow irrigation showed a small but non-significant advantage in water use efficiency with drip but no yield difference between methods. This suggests that under trial or commercial conditions which give abnormally high water use efficiency with furrow irrigation there is no significant benefit from drip irrigation.

In the row spacing trial planting at 1.65 m compared to 1.5 m spacing gave similar yields for six varieties showing that some reduction in tape costs could be achieved by moving to wider row spacing. The dual row planting on 1.8 m centres with one tape per two rows gave poor yields due to crop establishment problems but other trial work suggests that this is also a viable alternative for reducing tape costs.

Management techniques such as regular chlorination of drip tape and application of trifluralin through the tape to prevent root intrusion into emitters adopted for the trial are recommended as standard practice for drip users to ensure longevity of the drip tape.

1.0 BACKGROUND

The concept of drip irrigation is not new to the Australian sugar industry and commercial installations date back to the 1970s (Nicholson, 1977; Chapman, 1978). Drip irrigation was not widely adopted at that stage due to factors such as cost, susceptibility of tapes to blockage or damage, and limited experience in design and management of drip irrigation systems.

However, the sugar industry in Hawaii has improved the technology and was irrigating 34 000 ha of cane by drip irrigation. Improvements in tape longevity and drippers that minimise root intrusion and blockages made the system viable for Hawaii. At the time of commencement of this project drip was beginning to expand again in Australia, particularly in the Bundaberg area where drip has been used for some time in horticultural crops. The expansion was made possible by improved tape and system design, refinement of management practices and competitive marketing of drip tape.

At this stage there was still limited information available on some aspects of drip irrigation management - such as fertiliser application strategies, efficiency of water utilisation, tape placement, row spacing and irrigation scheduling. There was also limited information on performance in marginal soil types such as sands and hard setting soils.

This project aimed to fill some of these gaps in management knowledge.

2.0 OBJECTIVES

- To compare the yield responses from drip irrigation systems with spray or flood irrigation of cane.
- To compare the effects of fertiliser application method and application rate under different irrigation regimes.
- To evaluate alternative row spacings in order to reduce the capital costs of drip irrigation.
- To determine optimum positioning of drip irrigation tape relative to the cane sett at planting.

3.0 METHODOLOGY

The trial program was conducted at two locations, a krasnozem soil near the Hummock in Bundaberg and a gley podzolic soil on the Piersen Memorial Trust Farms in the Isis Mill area. All drip tape used in the trials was 16 mm diameter with 0.4 mm wall thickness and 0.6 m dripper spacing, installed underground with subsurface header and flushing mains.

3.1 Tape placement trials

Two trials were established on contrasting soils to determine whether tape placement was critical to crop performance; a clay soil (krasnozem) and a sandy loam (gley podzolic). These soils had 45-50% clay and 12-16% clay, respectively, in the topsoil. The trials included typical commercial installation techniques designed for particular circumstances;

placement under the sett at planting, placement beside the row behind a coulter and tine, and deep placement under the row prior to planting to allow replanting over the tape after ploughout of the first crop.

3.2 Krasnozem trial

The trial on the krasnozem soil compared two depths of placement: 100 mm below the sett depth but offset 70 mm, and 200 mm below the sett. The block was pre-ripped to locate any subsurface rocks before installation of the tape. Plot size was 5 rows x 184 m with five replicates per treatment, and two extra replicates included in the deep placement treatment to allow replanting over the tape. The trial was planted with the variety Q144 in spring 1991. The deep and shallow treatments were watered separately for the initial irrigation but then together for the remainder of the trial. Irrigation was scheduled using Class A pan evaporation and estimated crop canopy factors. Soil moistures to 1.3 m were measured in the plant crop using a neutron moisture meter. Water applied was measured using a water meter. After the plant crop, 2 row sections in the two additional deep placement plots were ploughed out and replanted to demonstrate the feasibility of planting over tape. Yields in the plant, first and second ratoon crops were measured using bin weights for each replicate.

3.2.1 Gley podzolic trial

The tape placement trial on the gley podzolic soil included three treatments:

T1 tape 100 mm below sett depth and offset 100 mm
T2 tape 100 mm below the sett
T3 tape 250 mm below the sett

The tape was injected after planting in T1 and just prior to planting in T2 and T3. Plot size was five rows x 150 m with four replicates per treatment. Planting was carried out with the variety Q136 in September 1992. Nitrogen and potassium fertiliser was applied through the tape as outlined for the irrigation method x fertiliser application trial. Cane yields and ccs were determined at harvest in late October 1993, early September 1994 and late September 1995. Yields in the middle three rows were measured with the BSES weigh truck. Six stalk samples were taken for ccs determination.

3.3 Irrigation method x fertiliser application trial

This trial was located on the gley podzolic soil adjacent to the tape placement trial, also using the variety Q136. The trial was designed to compare furrow versus drip irrigation, and conventional fertiliser placement with split applications through the drip system, treatments being:

T1	Furrow irrigation:	140, 180 kg N/ha applied conventionally
T2	Drip irrigation:	140, 180 kg N/ha applied conventionally
T3	Drip irrigation:	70, 90 kg N/ha applied through the drip system
T4	Drip irrigation:	105, 135 kg N/ha applied through the drip system
T5	Drip irrigation:	140, 180 kg N/ha applied through the drip system

Each treatment was replicated four times with a plot size of five rows x 150 m. The two nitrogen rates in each treatment are for plant and ratoon, respectively. Nitrogen applied through the drip system was split into four applications applied at approximately three week intervals in the plant and second ratoon crops and four week intervals in the first ratoon crops. In the plant crop, 20 kg N/ha was applied to all treatments at planting in September 1992, together with all phosphorus for the crop cycle. The remaining N was applied in December (conventional) or as split applications in December, January and February. For the first ratoon crop conventional application of nitrogen was in early December and split applications in December, January, February and March. For the second ratoon conventional application was in October. The split N fertiliser was applied as 50% in October and the remaining 50% in equal applications in November, December and January. In the conventionally fertiliser plots potassium was applied with the nitrogen application and in fertigated plots as split applications during nitrogen injection. Fertiliser application dates and harvest dates are listed in Table 1.

TABLE 1
Fertiliser application dates for irrigation method x fertiliser application trial and harvest dates

Operation	Date		
	Plant	1R	2R
Conventional fertiliser applied	14.12.92	6.12.93	18.10.94
First split N, K	18.12.92	14.12.93	20.10.94
Second split N, K	6.1.93	11.1.94	16.11.94
Third split N, K	20.1.93	9.2.94	19.12.94
Fourth split N, K	8.2.93	9.3.94	18.1.95
Harvest date	27-28.10.93	6-8.9.94	28-29.9.95

Watering was scheduled where possible using Claas A pan evaporation, with approximately weekly applications in the drip irrigated plots and fortnightly applications in the furrow irrigated plots. Water applied was calculated from pump hours and tape output in T2-T5, and from measured furrow flow rate and irrigation duration in T1. Third leaf samples were taken in late March 1993, early April 1994 and December 1994, January 1995 and March 1995 for assessment of nitrogen uptake in the plant, first and second ratoon crops. Harvest details are the same as those for the tape placement trial.

3.4 Row spacing trial

A row spacing trial was established at the same gley podzolic site to determine whether tape costs could be reduced by using wider than standard row spacings. Treatments were 1.5 m and 1.65 m row spacings (T1, T2) and dual rows at a spacing of 1.83 x 0.3 m (T3) with four replicates of each treatment.

Overall plot size was 5 rows x 150 m with plots split into 30 m sections by varieties Q136, Q138, Q150, Q151 and Q155. T1 and T2 were planted with a billet planter and T3 with a modified drop planter. Germination was poor in T3 so gaps were filled with plants grown from setts in January 1993. Fertiliser was applied through the tape as for the tape placement trial. Harvest details are the same as for the tape placement and irrigation x fertiliser trials.

4.0 RESULTS AND DISCUSSION

4.1 Tape placement trials

Results for the two placement trials show no significant effect of depth of tape placement on yields for either the krasnozem or the gley podzolic soil (Table 2).

TABLE 2
Yield (tonnes cane/ha) in tape placement trials on the krasnozem and gley podzolic soils for P, 1R and 2R crops

Treatments	Yield tonnes/ha			
	1992	1993	1994	1995
Krasnozem				
Deep tape	82.9	153.2	144.7	-
Shallow tape	84.8	155.4	142.3	-
lsd 5%	ns	ns	ns	-
Gley podzolic				
Deep tape		121.4	113.9	71.3
Shallow tape - beside row		125.8	115.1	79.2
Shallow tape - under row		124.6	115.0	80.0
lsd 5%		ns	ns	9.1

At the krasnozem site, monitoring of soil moisture levels in the plant crop using a neutron probe showed similar water usage patterns in shallow and deep placement plots, and confirmed that water usage matched well with that predicted from Class A pan evaporation (Table 3). Water usage was estimated from neutron probe readings, irrigation and rainfall using a simple water balance to account for losses of water by deep drainage. The neutron probe readings also confirmed that the wetting pattern was displaced deeper in the profile with the deep placed tubing.

Total water application through the drip system was 387 mm for the shallow tubes and 410 mm for the deep placed tubes. The difference was due to additional water applied immediately after planting, in order to achieve initial wetting up of the surface soil from the deep placed tubes. A similar wetting strategy is necessary at ratooning if there is no rainfall to wet surface soil. This can be a negative factor with limited available water.

After the plant crop at the krasnozem site, two rows in the extra replicates in the deep placement trial were ploughed out, and replanting was carried out successfully without damage to the tape. Subsequent growth in these rows was satisfactory indicating that tape watering efficiency was not impaired.

TABLE 3
Estimated water use in deep and shallow tape placement treatments in the krasnozem soil, compared with cumulative Class A pan evaporation adjusted for crop canopy development

Date	Estimated pan factor	Cumulative water use (mm)		
		Adjusted Class A pan	Shallow tape	Deep tape
25.11.91	0.3	16.7	26.8	33.8
9.12.91	0.4	51.1	94.8	63.8
6.1.92	0.5	155.9	166.0	153.0
15.1.92	0.5	194.2	218.0	213.0
20.1.92	0.55	216.3	248.4	235.4
28.1.92	0.6	254.7	287.4	275.4
3.2.92	0.6	282.2	299.9	297.9
10.2.92	0.6	310.4	333.1	333.1
25.2.92	0.65	365.7	409.5	381.5
2.3.92	0.7	390.8	433.3	419.3
9.3.92	0.7	421.2	459.5	447.5
24.3.92	0.75	480.0	515.5	491.5
30.3.92	0.8	504.9	530.7	506.7

While deep placed drip tubing performed well in both trials, some problems have been experienced commercially on sandy soils. There is a trend to lower yields in the deep placed tape plots in the gley podzolic soil but this did not reach statistical significance. Monitoring of commercial installations has shown that the surface soil is not wetted effectively under dry seasonal conditions, and that a dripper spacing closer than 0.6 m is desirable to give uniform watering along the row. While wetting patterns can be improved by applying smaller amounts of water more frequently, deep placement of tubing is not recommended on coarse sandy soils. In all soil types it is preferable to place the tape at 100-150 mm below planting depth rather than 200-250 mm as used in the deep placement treatment in these trials.

Neutron probe data from the gley podzolic site indicated a soil moisture storage capacity of approximately 40 mm to a depth of 700 mm.

At peak water use this storage capacity would require watering once per week if the wetted area extended fully across the interspace. Since the wetted area in this soil type with drip irrigation would at most be 50% watering once per week is likely to have caused water stress. Only limited tensiometer data was obtained for the trial and this indicated a reduction in growth at 40 cbar tension. Full monitoring of soil moisture tension during crop growth was not carried out.

4.2 Irrigation method x fertiliser application

Harvest results for this trial are given in Table 4.

TABLE 4
Harvest yields for the irrigation method x fertiliser placement trial on the gley podzolic soil

Treatment	Cane yield t/ha			CCS			Sugar yield t/ha		
	P	1R	2R	P	1R	2R	P	1R	2R
Conventional placement									
T1 Furrow	124.0	110.6	87.4	14.25	13.18	14.93	17.67	14.58	13.05
T2 Drip	129.0	117.6	79.7	14.20	13.11	15.38	18.32	15.42	12.09
Fertigation									
T3 (70, 90 kg N/ha)	120.6	94.7	57.1	14.04	12.95	15.23	16.93	12.27	8.73
T4 (105, 135 kg N/ha)	126.6	112.9	79.6	15.20	12.87	15.78	19.24	14.53	12.56
T5 (140, 180 kg N/ha)	131.4	108.3	70.4	13.30	12.40	14.79	17.51	13.43	10.45
lsd 5%	ns	11.3	16.1	ns	ns	ns	ns	2.36	4.13

In the first and second ratoon crops cane yield was significantly reduced in T3 where half the recommended rate of nitrogen was applied through the drip system. There was no significant difference in yield between conventional N fertiliser application at the full rate (T2), split applications at the full rate (T5) and split applications at 75% of the full rate (T4). This suggests that split application through the drip system may allow some reduction in fertiliser rates. However, no definite conclusion can be drawn as only one rate of nitrogen was applied conventionally.

There was a general trend towards lower ccs where the full rate of nitrogen was applied as split applications through the drip system. This suggests that split applications should be completed prior to the end of December if the full nitrogen rate is applied. There was no ccs depression at the 75% nitrogen rate and this was reflected in higher sugar yields than for the full nitrogen rate.

The results of the third leaf sampling for nitrogen analysis are given in Table 5.

TABLE 5
Third leaf nitrogen analysis for the irrigation method x fertiliser placement trial, sampled in late March 1993 (plant), early April 1994 (first ratoon) and late March 1995 (second ratoon)

Treatment	Third leaf N5 D.M.		
	P	1R	2R
T1	1.84	1.72	1.67 (1.70)
T2	1.86	1.77	1.75 (1.65)
T3	1.78	1.62	1.35 (1.34)
T4	1.88	1.76	1.39 (1.58)
T5	1.77	1.63	1.44 (1.60)
lsd 5%	ns	ns	0.26

*( ) December sampling

In the plant and first ratoon crop there was no apparent effect of nitrogen application method or nitrogen rate on third leaf nitrogen levels in March/April. The second ratoon third leaf nitrogen levels in March were significantly lower where nitrogen was applied through the drip system (T3, T4, and T5). This is in contrast to an earlier sampling in December where differences were much less apart from the half nitrogen rate (T3). It is not clear why final nitrogen levels in third leaf were reduced by applying half the recommended rate initially and the remaining half in three splits four weeks apart.

Water applied, effective rainfall and water use efficiency for drip and furrow irrigation is summarised in Table 6.

TABLE 6
Water applied, effective rainfall and water use efficiency for drip and furrow irrigation

Method/Crop Class	Effective rainfall (mm)	Irrigation (mm)	WUE* t cane/ML
Furrow			
Plant	650	590	10.0
1R	500	410	12.2
2R	501	200	12.5
Drip			
Plant	650	400	12.5
1R	500	330	13.5
2R	501	150	12.2

* calculated for effective rainfall plus irrigation

In each crop drip irrigation was marginally more efficient than furrow irrigation but yields were similar. The relatively high WUE for the furrow irrigation is considered atypical of commercial practice on this soil type and can be attributed to the short furrow length in the trial. In commercial situations differences in efficiency between drip irrigation and other irrigation systems can be more marked if the alternative system is being operated below optimum efficiency. A wide range of efficiencies has been noted with furrow and water winch irrigation on farms in the Bundaberg area. With tailwater recycling furrow irrigation can have similar water use efficiency to drip irrigation (Willcox *et al.,* 1997).

It is considered that water applied was below optimum in both the first and second ratoon crops due to difficulties in scheduling irrigation as required. In the second ratoon crop heavy rainfall in February (344 mm) resulted in severe waterlogging for a period of three weeks due to downslope seepage to the trial site. This may have been partly responsible for the relatively low yields in the second ratoon crop. The overall WUE for drip irrigation in the trial is lower than achieved in recent commercial best practice and this may be due to less frequent irrigation than required as discussed earlier.

4.3 Row spacing trial

The plant, first and second ratoon yields for the row spacing trial are given in Table 7. These are the means for the five varieties included in the trial. There was no significant interaction between row spacing and variety.

TABLE 7
Harvest yields for the row spacing trial in plant, first and second ratoon crops

Treatment	Cane yield t/ha			CCS			Sugar yield t/ha		
	P	1R	2R	P	1R	2R	P	1R	2R
1.5 m spacing	111.3	109.2	69.4	14.42	14.62	15.59	16.06	15.96	10.80
1.65 m spacing	113.9	116.0	74.7	14.28	14.05	15.55	16.31	16.30	11.59
1.83 x 0.3 m spacing	67.8	83.1	68.4	14.56	14.51	15.98	9.84	12.06	10.84
lsd 5%	25.4	ns	ns	ns	ns	ns	3.69	ns	ns

In the plant crop the yields were similar for 1.5 and 1.65 m spacings and inferior in the 1.83 x 0.3 m spacing. The relatively poor yield in the 1.83 x 0.3 m spacing was due to poor establishment caused by excessive cover at planting and erratic feed in the dual row planter. The planting effect became less noticeable in the first and second ratoon crops. Similar yields were obtained previously with 1.5 m and 1.8 x 0.3 m spacings in the plant and first ratoon crops of a cropping density trial at Bundaberg (Ridge and Hurney, 1994). Further trial evaluation of drip irrigation with dual row planting is warranted due to the potential savings on drip irrigation tape. The similar performance of 1.5 m and 1.65 m spacings is in line with other row spacing trials in south Queensland (Ridge and Hurney, 1994) and suggests that a 10% saving in tape costs is feasible without loss in yield. The wider row spacing is also more compatible with long-term retention of tape without damage from harvesting traffic.

Variety yields in the row spacing trial for first and second ratoon harvests are given in Table 8 together with mean yields over the two ratoons. Variety data was incomplete for the plant crop.

TABLE 8
Variety performance in the row spacing trial on the gley podzolic soil

Variety	First Ratoon			Second Ratoon			Mean		
	tch	ccs	tsh	tch	ccs	tsh	tch	ccs	tsh
Q136	113.9	14.14	16.1	75.3	15.62	11.75	94.6	14.72	13.93
Q138	99.7	13.94	13.9	75.4	15.54	11.68	87.6	14.60	12.79
Q150	98.8	14.07	13.9	79.7	14.91	11.86	89.3	14.42	12.88
Q151	99.4	14.89	14.8	67.6	16.13	10.91	83.5	15.40	12.86
Q155	102.0	15.00	15.3	56.2	16.32	9.18	79.1	15.47	12.24
lsd 5%	11.8	ns	1.3	16.1	0.74	ns			

Q136 was the best performing variety in the trial in terms of tonnes cane/ha and tonnes sugar/ha. The varieties Q151 and Q155 had the highest ccs but lower cane yields reduced their overall performance.

5.0 DIFFICULTIES ENCOUNTERED DURING THE PROJECT

The commencement of the trial program on the gley podzolic soil type was delayed one year by a change in plans by the farmer/cooperator in installing irrigation mains. Correct scheduling of irrigation became difficult in the second ratoon crop of the trial due to over-expansion of irrigation on the trial farm for the available water allocation. There were insufficient technical resources for the trial program to allow detailed supervision of watering and most of the drip irrigations were scheduled by the farmer. Timing of irrigations was sub-optimal in some cases. In the row spacing component of the trial program the dual row performance was adversely affected by poor establishment of the plant crop.

6.0 RECOMMENDATIONS FOR FURTHER RESEARCH

During the project it became evident that more information is required on scheduling techniques for drip irrigation matched to soil wetting patterns and the stage of crop canopy development. Also there is a need for related study of chemical placement through the drip system to ensure efficient fertiliser use, the ability to place insecticides and fungicides through tape, and to protect tape from damage by rats and other pests.

7.0 APPLICATION OF RESULTS TO THE INDUSTRY

The project results have been applied locally in Bundaberg with typical tape placement at 100-150 mm below cane setts for single row planting or midway between dual rows; injection of nitrogen and potassium fertiliser through tape, and limited adoption of dual row planting. With deeper tape placement additional watering to ensure wetting up of the root zone for plant cane establishment or ratooning has been adopted as a standard practice. These results have been circulated industry-wide through inclusion in a BSES Drip Irrigation Manual.

8.0 PUBLICATIONS ARISING

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