Queensland Government
Department of Primary Industries

RURAL WATER USE EFFICIENCY INITIATIVE

Case Studies

&

Farmer Learning's

"Irrigation for Profit"

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Appendix 5

Contents

Outcomes and Learning's - Dairy and Lucerne RWUE Program

(Presented Conference paper)

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ABSTRACT

The "Irrigation for Profit" program project of the Queensland Rural Water Use Efficiency Initiative (RWUEI) is targeting five major dairy and three major lucerne irrigation regions in the state. The objective is to develop better irrigation water use efficiency (WUE) through the adoption of best management practices in irrigation. The major beneficiaries of the program will be industries, irrigators and local communities.

There are major benefits of: increased productivity and profit resulting from improved WUE and, improved environmental health. The program has contributed to an improved public image of the dairy and lucerne industries.

In each of the regions, WUE officers have established grower groups to assist in providing local input into the specific objectives of extension and demonstration activities. The groups also assist in developing grower's perceptions of ownership of the work. Extension activities are centred around on-farm demonstration sites in each region where irrigation management techniques and hardware are showcased.

A key theme of the program is monitoring and scheduling of water use. Due to vast distances covered by the project this has meant introducing new remote monitoring technologies to farmers.

INTRODUCTION

Australia is a nation of vast extremes.

Australia is the driest inhabited continent even though some areas have annual rainfall of over 1200 millimetres. Our climate is highly variable-across the continent generally, as well as from year-to-year [6]. As such there is an ever-increasing need to enhance our water resource programs as our population grows. *Australia harvests, 'utilises', 5% of its surface water. Our irrigated agriculture uses approximately 70 to 80 percent of this resource [8].*

The dairy and lucerne industries account for approximately 10% of this use nationally (4% dairy, 6% lucerne) [7]. Hood [9] described WUE, in irrigated agriculture, as maximising the returns and minimising the environmental impacts for every megalitre of water used for irrigation purposes.

Figure 1. River discharge by continent (excluding Antarctica) related to rainfall supply, adapted from [5]

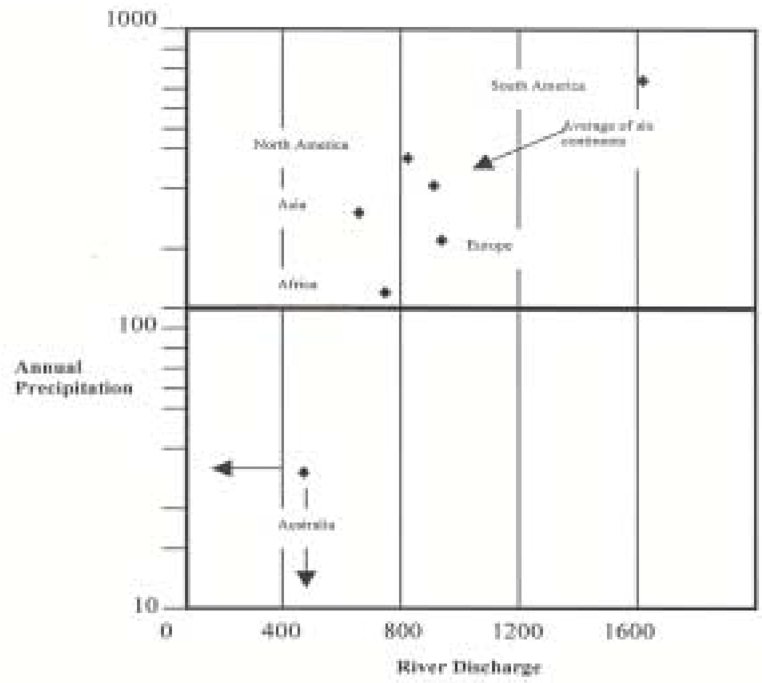

Figure 1 above shows the annual average river discharge in millimetres over annual precipitation in millimetres over continental area.

In 1999 the Queensland Government introduced a four-year program, the Rural Water Use Efficiency Initiative (RWUEI) [4].

Queensland Department of Primary Industries (DPI) Agency for Food and Fibre Sciences' Intensive Livestock and Sheep Institute, is undertaking the "Dairy and Lucerne Adoption Program" within the irrigated dairy and lucerne industries. The program is being conducted as part of the RWUEI in partnership with the Department of Natural Resources and Mines (NR&M). 'Irrigation for Profit' is the localised team name for the dairy and lucerne adoption program.

The objective of this adoption program is to help Queensland dairy and lucerne irrigators measure, record and monitor their progress in WUE improvement, thus aiming to increasing, irrigation efficiency by at least 11%, with 40% of growers adopting Best Management Practice (BMP) for irrigation by June 2003.

The Program has industry ownership through and is administered by Queensland Dairyfarmers Organisation (QDO) in Brisbane. It is being supervised by and takes direction from a consultative committee, which includes all major stakeholders. Similar programs are also being conducted in the cotton and grains, sugar, and the fruit and vegetable industries in Queensland.

METHODS

Five major dairy and three lucerne irrigation regions in the state are being targeted. These extend from Atherton in North Queensland, Beaudesert in the southeast Queensland, St George in the west of Queensland and Texas on the Queensland and New South Wales border.

In each region, WUE officers have established grower groups to assist in providing local input into the specific objectives of extension and demonstration activities. The groups also assist in developing growers' perceptions of ownership of the work. Activities are based around at least six and up to twelve on-farm demonstration sites in each region, where irrigation management techniques and hardware are showcased. A key theme of the program is monitoring water use. This is applied both to distribution as well as to application methods and in-field management.

The dairy and lucerne WUE officers are conducting an education program for farmers which includes:

- Establishing an annual award system which provides incentives and opportunities to improve WUE and which recognises individual farmer achievements or initiatives that have led to improved WUE.
- Developing, demonstrating and promoting the implementation of the water monitoring systems on farm using simple practical methods and devices, in remote areas utilising remote telemetry (both digital and analogue/CDMA)
- Developing a strong awareness of all water management issues.
- Conducting surveys at strategic times on specific issues during the project to evaluate performance and delivered outcomes of significant to program outcomes

Figure. 2 Shaded areas indicate the main irrigated dairy and lucerne areas of Queensland

To address some of the many issues confronting irrigators, 42 demonstration or trial (benchmarking) sites were established during 2001/2002. Irrigated crops and pastures involved were: maize, oats, barley, sorghum, lucerne, rye grass, clover mixes, kikuyu and other tropical grass pasture mixes. Irrigation systems included, centre pivot, subsurface drip, side-roll sprays, lateral move, travelling gun and hand shift systems. In addition, trials were established to investigate the control of water loss due to deep percolation beyond the root zone caused by over-irrigation. The program team carried out similar activities in previous years.

A Financial Incentives Scheme (FIS) that partly subsidises growers for their outlays is assisting the implementation of the adoption of new irrigation technologies. This scheme (with farmer inputs) invested $7M into dairy and lucerne irrigation infrastructure within its first two years of operation. This has aided rapid change in increased efficiencies WUE.

PROGRESS AND DISCUSSION

Because of the program, an increasing number of irrigators are now achieving irrigation efficiencies well in advance of the State benchmarks presented in stocktake reports [2,3], which was compiled in the early stages of the program. These efficiency gains indicate that the 11% target increase in efficiency set for the program is being achieved and in many cases exceeded.

Up to December 2002 the project has had 75% participation of irrigators in extension activities including field days, workshops and farm visits, 27% who have had their irrigation systems audited for Distribution Uniformity (DU), pumping efficiency, pumping costs ($/ML) and application rate, and 51% who have used the FIS to make improvements to their irrigation efficiency.

Our best opportunity for water savings lies with accurate measurement. Through project officer guidance and measurement, our trial site co-operators have investigated various management options and eventually set their own targets for improvement. There has been a growth in irrigation scheduling tools being utilised to effectively time irrigations, but they are yet to be used to their full potential. If these tools are correctly calibrated they can be used to show the irrigator how much water needs to be applied and the appropriate duration and timing of irrigations.

Through demonstration sites and research trials the industry has established benchmarks for agronomic water use efficiency. The following table shows the data collected from demonstration sites over a winter growing season compared to the Barraclough stocktake figures.

Table 1. **Current trends against the Barraclough dairy benchmarks** [2].

	Production/ ha	Irrigation	Rainfall	Litres Milk/ML	$/ML
2002	7810 litres	2.96ML	1.5ML	1751l/ML	$542/ML
1997	6515 litres	3.75ML	1.5ML	1240l/ML	$384/ML

The above table demonstrates a 30% increase in the economic water use index. We have used $0.31 as the price for a litre of milk in both calculations. In 1997 farmers were being paid $0.58 for their quota milk (averaged 50% of production) and $0.31 for manufacturing milk. In 2002 they are being paid $0.31 for all their milk. Although the last litre cost remains the same for calculating economic efficiency, in absolute terms their incomes have decreased significantly (25 to 30%) and their profit margins drastically. It is important to note that the Queensland dairy industry went through deregulation during these years and this had a major influence on dollars returned.

Across the industry we have used a triangulation method to establish water use efficiency gains. A survey was conducted of 500 farmers who had made changes on their farm directly as a result of the “Irrigation for Profit" project. The results show an increased production of 5.3% while using 3.4% less water. This equates to an 8.7% improvement (Approximately AUD$7M) in water use efficiency across the dairy and lucerne industry in 2002.

The following dairy farm case studies highlight the importance of soil moisture monitoring and measurement in irrigation management:

- Changing a traditional farming practice of applying 120mm of irrigation before planting ryegrass. The use of a scheduling tool was able to show that only 30mm was required to fill the profile, saving 0.9ML per hectare in one irrigation event. This farmer has also reduced his traditional 65mm irrigation application to 25mm, allowing him to take advantage of small rainfall events. Irrigation water use has been halved in a relatively dry year.
- A farmer using a travelling irrigator has changed from applying 45mm every 21 days to 30mm as indicated by an EnviroSCAN®. They have also changed from a ring to a tapered nozzle to improve distribution uniformity. Production has increased by 20% using the same amount of water. The majority of deep drainage has been eliminated.
- Most solid set irrigation systems in Queensland have been installed with a single jet nozzle. The Irrigation for Profit team has identified the opportunity to improve distribution uniformity (DU) on most solid set systems by installing a back jet (and modifying the front jet if required). One example improved DU% from 60% to 75%. This meant that 15% less water needed to be used to apply the same evenness of application.
- Many farms with centre pivots have not been replacing nozzles with the correct size. One farm was able to increase DU% from 70% to 85% by installing the correct nozzles. Most centre pivot owners are now aware of this issue.
- With planning assistance from the ‘Irrigation for Profit’ project the first centre pivot has been installed in the Wide Bay dairy industry. The labour requirement has been reduced significantly and initial production measurements are very positive (2000 kg DM/ha increase).
- Through a consistent awareness campaign most farmers now aim to apply between 20 and 30mm per application to ryegrass. Five years ago it was common for farmers to aim to apply up to 75mm. Actual measurement with catch cans is showing that a perceived 25mm (based on advice at installation) is actually varying from 20mm to 50mm. Many farmers have changed their irrigation application based on actual measurement as opposed to a design specification.

The following case studies from lucerne farm demonstration sites highlight the importance of soil moisture monitoring and measurement in irrigation management:

- Using soil moisture data for management, a Texas farmer has commenced applying two x 25mm irrigations over two days through his centre pivot irrigator, as a means of preventing irrigation water losses to deep percolation past the root zone. The EnviroSCAN® soil moisture probes clearly demonstrate the success of this strategy. His comment - "We can see from the graphs when irrigations should occur as soil moisture approached the 'onset of stress line'".
- Records kept at Biloela indicate that, on similar soil types on their farm, a hand-shift irrigator delivering a total of 432mm produced a similar tonnage of hay to their SDI system, which delivered 271mm - an increase in agronomic efficiency of 63%. Their comments - "We are just wasting water with our old hand-shift system". A 2m deep EnviroSCAN® probe was requested by our co-operator to monitor suspected water losses to deep percolation. Irrigations of 12-hour duration have been adopted. This probe demonstrated there was no real water loss below 1.6m depth. Their previous practice was to irrigate for 24-hour duration.
- An Inglewood farmer has used his EnviroSCAN® installation to confirm that there is no loss of water to deep percolation, as was suspected. The EnviroSCAN® has also assisted him to better gauge the peak water demand of his lucerne during summer. This has lead him to conclude that he would be better off by reducing his irrigated area from 20ha to 12ha to better cater for peak water demand during summer. System checks have revealed a need to improve pump efficiency and DU% of the side-rolls. He has rectified some installation faults in the piping from the pump, increasing pumping efficiency by 5%. New double-jet nozzles fitted in an effort to improve DU, have shown measured DU improvements from 65% to 90%.
- A Pilton farmer has used the Financial Incentive Scheme to purchase a new rotary nozzle package for his low pressure travelling boom irrigator. This has increased DU% of his system from 64% to 78%. The initial system check also revealed that speed of travel was not constant. This matter has been highlighted with the manufacturer and investigations have commenced to rectify that problem. The Enviroscans installed have clearly demonstrated the moisture-holding characteristics of soils here. Consequently, the co-operator has learnt that his system is unable to supply the current area of lucerne with sufficient water to satisfy peak crop demand in summer. This has lead to the conclusion that the irrigated area should be reduced for most efficient production. He has also stated an industry need to have manufacturers more closely involved in maximising system efficiencies from the outset.
- Laidley farmer has changed from a high-pressure travelling gun system to a lower pressure hand-shift system following initial system checks and associated power costing. Power costs have been reduced from $41.91 to $27.05/ML. By using output from the EnviroSCAN® monitoring system, this co-operator has learnt of the 'old' system's inability to supply the irrigation peak demand. The old system could apply only 7.7mm/h, vs the 'new' system's 14.8mm/h. Distribution uniformity has also been improved from 74.8% to 80.2%. This should all amount to improved yields and quality - achieved at a lower cost /tonne. Production records are expected to confirm this.

SOME OVERALL HIGHLIGHTS TO DATE

The RWUE "Irrigation for Profit" program is achieving very significant outcomes towards the better management of irrigation water in both the dairy and lucerne industries. These include:

- Awareness and participation in the program exceeded 75% of irrigators
- A survey conducted in May 2002 indicated that 68% of dairy and lucerne irrigators had become involved in best management practices.
- An increasing number of irrigators are now achieving irrigation efficiencies well in advance of the State benchmarks determined at the commencement of the program.
- The long-established benchmark for lucerne agronomic water use efficiency is 0.73ML/tonne of lucerne hay. The case studies to date have revealed agronomic efficiencies under well managed systems of:
  - 0.4ML/t - centre-pivot system (Texas)
  - 0.5ML/t - Travelling Boom (Pilton)
  - 0.55ML/t - Sub-surface drip irrigation (SDI) system (Biloela)
  - 0.59ML/t - side-roll irrigator system (Inglewood)
  - 0.78 ML - solid-set system (Mutdapilly Research Station Trial, 2002)
  - 0.9ML/t - hand-shift system (under extreme temps. and water availability - Monto)

- Results indicate a gradual improvement in water use efficiency across the state. The improved management practices that have resulted in these trends represent real and practical opportunities for all irrigators to improve their WUE.

PROGRAM EVALUATION

The impact of the RWUE program is being generically evaluated in relation to its influence on improvement in WUE also the across industry move of irrigators towards BMP, and their awareness of and participation in these program. The following areas are being closely monitored:

1. Economic
2. Environmental and;
3. Social benefits.

An independent evaluator carried out a mid-term evaluation of the program's performance in September 2001 and a final evaluation will be made on completion of the Program [1].

The final evaluation will:

- survey 10% of industry to gauge an accurate measure of improvement
- report outcomes and outputs against agreed measures and targets
- report on accuracy of the data within all programs
- using the data accumulated, undertake a benefit/cost analysis of the program
- report on reasons for successes and failures

Importantly

- provide recommendations for future actions to improve performance in WUE

CONCLUSIONS

Dairy and Lucerne Irrigators have recognised the relationship between their industry's economic development, 'sustainability' and its impact on their environment from rural pasturelands to the coast. Better Management Practices are being developed and applied in a continuous improvement cyclic manner.

The dairy and lucerne "Irrigation for profit" program team is continually encouraging irrigators to focus on the accuracy r of their application of irrigation water applied. An ever-increasing number of pasture irrigators are now using scheduling tools to determine when and how much water to apply and so deliver to the root zone exactly what the crop requires. There is also now an increased use of water meters. These tools assist in minimising or eliminating runoff from the fields and drainage losses beyond the root zone, thus preventing the development of salinity and waste of irrigation water.

Although the program has been in place only since 1999 the dairy and lucerne adoption program team is making real progress in influencing irrigators to become more aware of their water use and assisting them in making those management changes, which will enhance irrigation efficiency.

Irrigators in both the dairy and lucerne industries have increasingly become more highly motivated to proceed with management changes, which have been identified by the program, which will increase irrigation efficiency. As with other industries working in this area they need continued guidance a to maintain this motivation and implement their new management strategies that will benefit industry and the state.

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Improving the yield of annual ryegrass using nitrogen fertiliser spread in accordance with degree-days on the Atherton Tablelands.
(Paper in progress by Brad Silver)

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INTRODUCTION

Annual ryegrass (*Lolium multiflorum*) is the major forage grown on dairy farms in the tropics and sub-tropics of Queensland under irrigated conditions. It is a highly productive, high quality forage, which has had a significant impact on milk production since it was introduced in the late 1970's. However it wasn't until the early 1980's that significant increases in ryegrass areas were planted which significantly boosted the winter milk production on the Atherton Tablelands (Itzstein *pers com*).

An audit (Barraclough & Co.) conducted in 1997 estimated that 26,906 ha were irrigated in the winter in Queensland as dairy pasture for a total production of 320 million litres of milk. On the Atherton Tablelands approximately 20 million litres of milk was produced off 1600 ha of irrigated winter pasture at a current value of $6.4 million.

The Queensland dairy industry uses approximately $8M worth of nitrogen fertiliser annually mostly in the form of urea (Lowe, 1996). A large proportion of this fertiliser is used to promote the growth of annual ryegrass. Current recommendations for the application of nitrogen fertiliser to annual ryegrass a pasture is 57 kg N/ha after each grazing when on a 3 weekly grazing rotation. At this rate a total of approximately 450 kg N/ha would be spread over the ryegrass season.

These fertiliser rates where based on experiments conducted on irrigated oats in the late seventies (Lowe, Bowdler and Batianoff, 1980) and some on farm work and have largely remained the same since. In the late seventies recommended rates of nitrogen on temperate pastures were 86 kg N/ha/month (Spackman & Cook, 1979 and Smith *et al*, 1979). In an on-farm trial conducted by Hawley and Harris in 1980 comparing nitrogen fertilised ryegrass with a ryegrass/clover mixture and a pure clover treatment, the most productive and most profitable treatment was the ryegrass nitrogen treatment. In this trial the ryegrass was topdressed with varying amounts of nitrogen ranging from 46 to 80 kg/ha for a total of 310 kg N/ha.

More recent work by Lowe *et al* (1996) concluded that at the rate of 50 – 60 kg N/ha applied every three weeks, dry matter yields will reach about 90 % of their potential, there is little chance of poisoning stock from plant nitrate and there will be insignificant increases in soil N. The current recommended rate falls within the range suggested by Lowe (1996).

However even though the growth rate of annual ryegrass can vary from 25 kg DM/ha/day in winter to 80 kg DM/ha/day in spring the recommended nitrogen application rate remains the same after each grazing. Ideally the grazing rotation length should vary in accordance with the growth rate of the pasture. Fulkerson (1997) recommends grazing annual ryegrass at the 3 leaf stage to maximise dry matter production. Using this criterion the grazing rotation length could vary from 28 days in the winter to 16 days in spring. This is sometimes difficult to achieve as grazing area and stock numbers do not usually vary much through out the season.

However, being fixed to a set rotation length and nitrogen fertiliser rate through out the season risks the possibility of nitrate poisoning of stock. Ryegrass plants usually luxury feed under conditions of non-limiting nitrogen and water and store the surplus nitrogen in various forms in the plant tissue. The uptake of nitrogen appears to be quite rapid and excess nitrogen initially accumulates in the plant leaf were it is available for growth. If the plant is grazed before the excess nitrates are utilised for growth the excess nitrates are consumed by the dairy cow leading to the condition methaemoglobin. Plant levels greater than 2000 ppm of nitrates in the plant sap are considered to be potentially toxic to cattle although the level of carbohydrate in the ration appears to have an effect on the toxicity of nitrate (Lowe *et al*, 1996).

Therefore it is desirable to have a scheduling tool for nitrogen application during the growing season, applying nitrogen more in line with plant requirements. This project tests the concept of degree-days as a scheduling tool for nitrogen application. There are different ways of calculating degree-days but the simplest is to average the maximum and minimum temperatures for a particular day. For example, on a day with a 4^{o}C minimum and a 16^{o}C maximum temperature, 10 degree-days would be recorded. A day with a 10^{o}C minimum and 26^{o}C maximum equates to 18 degree-days.

The principle underlying the degree-day concept is that ryegrass growth and therefore nitrogen use is influenced by the environmental temperature. The greater number of degree-days between nitrogen applications the greater will be the nitrogen use by the plant. Similarly, as temperatures cool plant growth slows and hence nitrogen requirement is less.

The object of this trial was to explore the concept of using degree-days to determine that rate of nitrogen application to annual ryegrass with the aim of increasing the efficiency at which the nitrogen was used. The results of this experiment could significantly impact on the way nitrogen is applied to ryegrass throughout the tropics and sub-tropics.

This experiment was conducted during the winter of 2002 by members of the North Johnstone and Lake Eacham Landcare Association and was funded by the Queensland Department of Primary Industries, Agency for Food and Fibre Sciences, Rural Water Use Efficiency Initiative.

MATERIALS AND METHODS

Trial Site

This experiment was conducted on the farm of Russell and Cil Fry. The farm is situated approximately 10 km north east of Malanda and receives an average annual rainfall of 1650 mm. The farm has 36 ha of irrigation using both a centre pivot and permanent solid set. The soil type at the site is a free draining mesotrophic red ferrosol, Tolga, (Malcolm *et al.*).

An area of 20 m by 20 m adjacent to the solid set irrigation area was fenced and set up to receive irrigation independent to the normal farm irrigation system. The irrigation system was tested at a distribution uniformity (DU) of 85% at an application rate of 5 mm/hour. A tensiometer was installed in the plot area at a depth of 15 cm determine irrigation timing. Irrigations were commenced when the tensiometer read between –50 to –60 kPa and typically 18 mm was applied. At this application rate all of the water applied remained in the active root zone of the ryegrass plant. This application rate is also sufficient to infuse surface applied nitrogen into the soil.

The trial plots were established on a site with a southerly aspect and a slope of 1.15 m in 10 m. The ryegrass was planted on the 1st of May 2002 using mulch strike methods at a rate of 50kg/ha.

Determination of degree-days

An automatic weather station had been previously installed by the RWUE project on a farm approximately 5 km from the trial site. This weather station measured ambient temperature (maximum and minimum), rainfall, global radiation, relative humidity, leaf wetness, wind speed and wind direction and was used by the RWUE project to calculate evapotranspiration for ryegrass.

The degree-days were calculated as the average of the maximum and minimum temperature of a particular day as measured by the weather station. Therefore before the plots were fertilised the total number of degree-days since the last fertiliser application were calculated and the required amount of nitrogen was then calculated.

A relationship between degree-days and nitrogen rate needed to be established as no relationship could be found in the literature. This was done using temperature data for the previous four years from the Queensland Department of Primary Industries, Kairi Research Station. This data can be seen in Table 1.

Table 1: A summary of the degree-days at Kairi Research Station for the ryegrass growing season.

Kairi Research Station Degree-Days					
Month/Year	**1998**	**1999**	**2000**	**2001**	**Mean**
April (2 wks)	367	318	329	339	338
May	628	595	603	547	593
June	538	533	473	546	523
July	561	484	462	496	501
August	580	519	537	522	540
September	630	560	581	600	593
October	726	670	676	674	687
Total	4031	3680	3661	3724	3774
N @ 0.10 kg/DD	403	368	366	372	377
N @ 0.11 kg/DD	443	405	403	410	415
N @ 0.12 kg/DD	484	442	439	447	453
N @ 0.15 kg/DD	605	552	549	559	566
N @ 0.18 kg/DD	726	662	659	670	679

Treatments

Several possible nitrogen rates were applied to the degree-days data from the Kairi Research Station (Table 1). It was concluded that a rate of 0.12 kg N/degree day would be the degree-day treatment as the mean total application amount for the ryegrass growing season was 453 kg of nitrogen. This rate most closely equalled the recommended nitrogen application amount of 450 kg nitrogen.

As the weather conditions at the Kairi Research Station are slightly different from the trial site (normally wetter and cooler) it was necessary to establish a second degree-days based treatment to overcome site differences.

Four treatments were therefore established.

1. Control treatment with no additions of N
2. Standard treatment of 57 kg N/ha every three weeks
3. Nitrogen applied at 0.12 kg N/ha/degree-day every three weeks
4. Nitrogen applied at 0.18 kg N/ha/degree-day every three weeks

Four replicates were used in a Latin square design with plots 5m x 5m. Soil tests over the trial area were taken prior to planting on the 1st of May 2002. On the 15th May CK66 fertiliser (11.5,12.8,18.0) was spread on the entire plot area at the rate of 250 kg/ha. The treatments were then imposed after the first harvest on the 5th of June. The layout of the trial can be seen in Figure 1.

Figure 1: **The layout of the treatments in the trial**

Treatment			
2	**3**	**1**	**4**
4	**1**	**2**	**3**
3	**2**	**4**	**1**
1	**4**	**3**	**2**

Pasture Yield

The pasture was harvested on a 21 day rotation using a mechanical sickle bar mower. Pastures were sampled to a height of 5 cm and harvested area was 2.9 by 1.05 m. Samples were immediately weighed. Sub-samples for dry matter determination were collected and dried at 80 ^{0}C for 24 hours.

After harvest the entire plot area was mown and raked off to remove any leftover plant material.

Determination of Plant Nitrate

On two occasions (harvests 5 & 7) plant samples were hand collected to test for plant sap nitrate levels using a Cardy® meter. Sap samples were squeezed from the plant material using a garlic press. Several measurements were taken from each plot.

At the same time separate plant samples were collected from the mechanically harvested material for laboratory analysis as a comparison to the Cardy® meter results. These samples were dried at 60 ^{0}C for 24 hours and ground through a 2mm sieve.

Pant samples were also collected for nitrogen analysis at the final cut (harvest 8).

Soil Nitrogen

On the 28th August, samples of soil were collected from each plot to a depth of 30 cm at 10 cm increments.

Samples were also collected from each plot at the conclusion of the trial on the 30th October to a depth of 40 cm at 10 cm increments.

These soil samples were dried at 40 ^{0}C, ground and analysed for NH_4-N and NO_3-N.

Statistical Analysis

Data generated by the trial work was analysed using either an general ANOVA or a repeated measures ANOVA.

RESULTS

Nitrogen Application Rate

Using the degree-days to determine the amount of nitrogen to be applied to the ryegrass proved to be an effective scheduling tool. As was expected the amount of nitrogen that was applied to the degree-days treatment plots varied throughout the ryegrass growing season. In Table 2 the amounts of nitrogen applied to each plot (converted to kg/ha) can be seen. This is graphically represented in Figure 2.

Table 2: The amount of nitrogen applied to each treatment at each date and the total in kg/ha

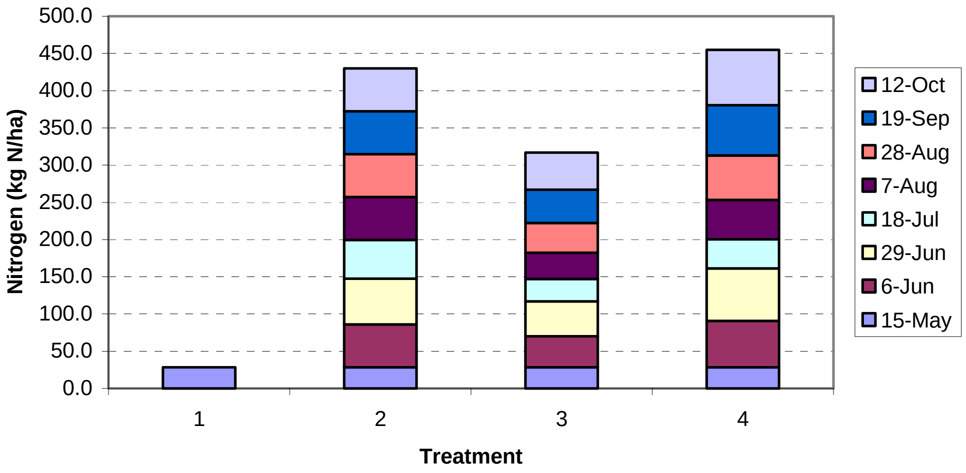
T'ment	15 May	6 Jun	29 Jun	18 Jul	7 Aug	28 Aug	19 Sep	12 Oct	Total
1	28.4	0	0	0	0	0	0	0	28.4
2	28.4	57.6	61.3	52.1	57.6	57.6	57.6	57.6	429.7
3	28.4	41.6	46.9	30.0	35.3	39.9	44.9	49.7	316.7
4	28.4	62.4	70.5	39.0	53.0	59.8	67.3	74.5	454.9

Using degree-days (at 0.12 kg N/degree-day) a total of 113 kg/ha less nitrogen was applied to the ryegrass when compared to the standard treatment (treatment 2). This was less than anticipated. One of the reasons for this is that the nitrogen application rate calculation included the last 2 weeks of April (assuming a mid-April plant), when the actual planting date was the 1st May. As can be seen from Table 1 the last 2 weeks of April averaged 338 degree-days, which is the equivalent to 41 kg N/ha at 0.12 kg N/degree-day.

Temperature data from Kairi Research Station shows that the year 2002 was close to the average of the previous 4 years. Therefore the difference in nitrogen application must be due to climatic differences at the trial site when compared to the Kairi Research Station data. These differences will need to be accounted for in further use of degree-days.

Applying nitrogen at the higher degree-day rate (treatment 4) resulted in an extra 25 kg/ha N spread over the growing season when compared to the standard treatment (treatment 2).

Figure 2: Accumulating and total nitrogen application amounts.



At the standard application rate (treatment 2) a total of 430 kg N/ha was applied. This was close to the expected total amount.

Irrigation Amount

Total irrigation for the trial period was 420 mm or the equivalent of 4.2 ML/ha. This was a similar total to irrigation applied to other farm paddocks.

Pasture Yield

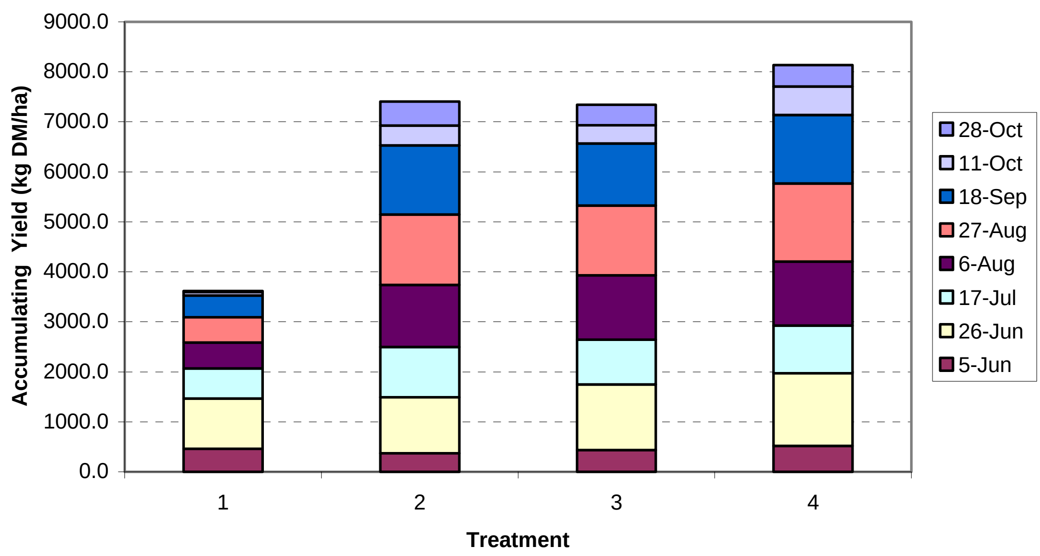
The ryegrass was harvested on a 21 day rotation with the first harvest being made on the 5th June. The results of the plot harvests can be seen in Table 3. The pasture yields are also graphically presented in Figure 3.

Table 3: The dry matter yields for each treatment at each harvest and the total in kg DM/ha

Treatment	5 Jun	26 Jun	17 Jul	6 Aug	27 Aug	18 Sep	11 Oct	28 Oct	Total
1	458	1008	602	517	506	435	72	22	3619[a]
2	370	1120	1004	1244	1407	1382	396	485	7408[b]
3	437	1310	899	1285	1395	1239	371	405	7341[b]
4	520	1450	957	1277	1565	1370	565	432	8136[b]
Lsd 5%									1201

There was no significant difference in pasture dry matter yield for treatments 2, 3 and 4 at each harvest or in total yield. However, the total yield of these treatments significantly out yielded treatment 1.

Figure 3: Pasture dry matter yield



The three treatments receiving a topdressing of nitrogen after each harvest produced an extra 3700 kg DM/ha (treatments 2 and 3) to 4500 kg DM/ha (treatment 4) over the treatment receiving no extra nitrogen (treatment 1). The response in total pasture yield to extra nitrogen applied equalled 8.2, 12.3 and 10.4 kg DM/kg N for treatments 2, 3 and 4 respectively (Table 4). Treatment 3 had a significantly higher response to extra N than treatment 2.

Table 4: The pasture dry matter response to extra nitrogen in DM kg/N

Treatment	Nitrogen Response	
2	8.2	a
3	12.3	b
4	10.4	ab
Lsd (5%)	3.2	

Soil Nitrogen

Table 5: Total N recovered to 40 cm in kg/ha on 30 Oct 2002.

Depth/T'ment	1	2	3	4
10 – 20	26.29	47.20	31.91	57.11
20 – 30	20.31	29.97	29.07	42.22
30 – 40	9.98	15.29	15.25	27.06
40 – 50	11.96	14.41	9.84	27.05
Total	68.56	106.88	86.08	153.44
Lsd (5%) = 48.28	a	ab	a	b

ACKNOWLEDGMENTS

This project was made possible with funding provided by the Queensland Rural Water Use Efficiency Initiative and that support is acknowledged.

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Case study – efficient use of water – a holistic approach or a tail of two farmers Ross Warren, Gympie

Comparison between the farming and management operations of the Farmer A and Farmer B dairy farms.

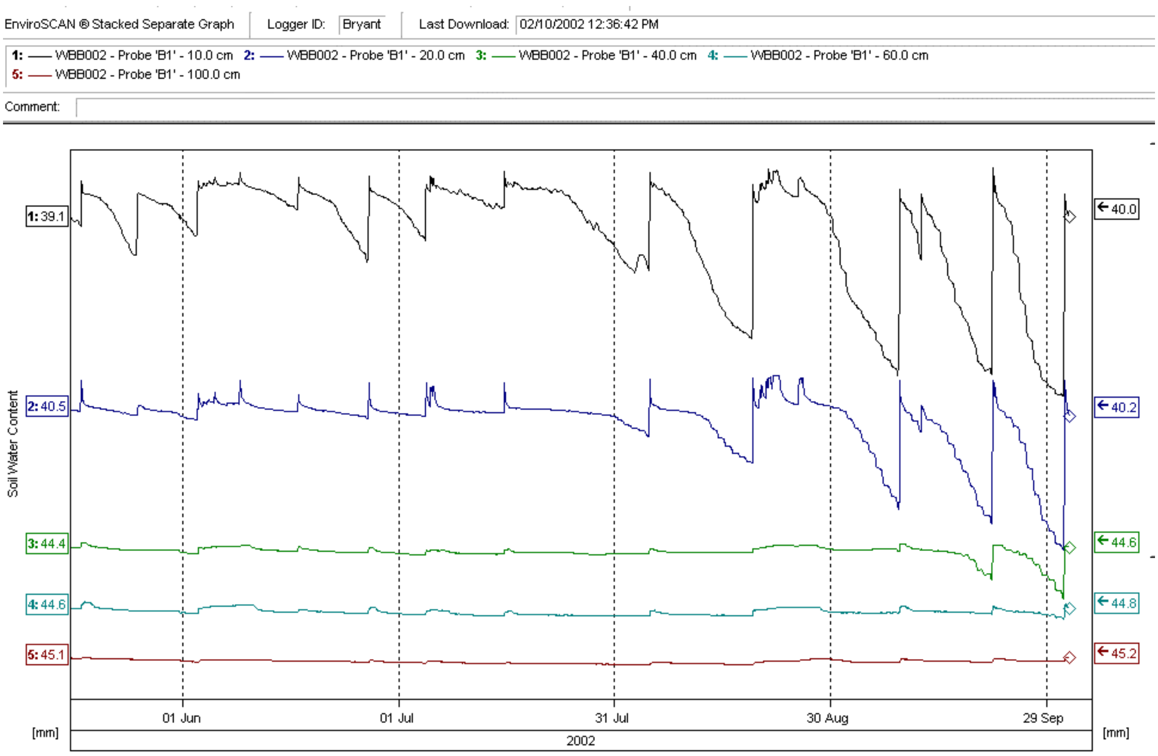
Background

1. Farm B in the Conondale district. B is in his mid 50's and is married two children at home. The B supply the Dairyfarmers cooperative. The family milk around 110 cows on 28 hectares of irrigation. B does not have any plans to expand his operation, his main concern is survival. The farm is situated on the upper reaches of the Mary River with no water allocation. The irrigation plant consists of solid set, hand shift, ezi-shift and a hard hose irrigator. B has been using an Enviroscan®, supplied by the project, to assist with water management; pasture measurements have been taken regularly throughout the ryegrass season of 2002. During 2001 & 2002 he has experienced severe water shortages with the river ceasing to flow periodically. The water advisory committee has imposed voluntary water restrictions with limited success; some irrigators above him on the river have continued full irrigation. His fertilizer program has not been as frequent as necessary due to financial difficulties associated with the drought. This has limited pasture growth and corresponding production. Cows were periodically fed about two kilograms of grain, with molasses the predominant supplement. There is no particular breeding program in place, no AI is used. A mixed herd of both Friesians and Jersey's are milked. B is actively involved in Landcare and other community groups. He is also on the upper Mary River water advisory committee and is a very keen supporter of our RWUE program.

2. Farm A in the Conondale district. They are younger than B. The milk is supplied to National Foods, they previously supplied Dairyfarmers. The decision to change supply was an economic consideration. The A milk around 280 with a plan to expand to about 350-400 cows over the next twelve months. A irrigates approximately 60 hectares using a Centre Pivot and traveling irrigators both hard and soft hose. An Enviroscan® and an automatic rain gauge have recently been installed under the pivot as part of the RWUE project. Pasture readings have been collected throughout the ryegrass season on the irrigated pasture. The A irrigate from two large on-farm water storages, one being built this last year. The estimated on-farm storage is 800 ML; there is approximately 120 ML in storage. They flood lift from the river during times of high rainfall. They have a definite breeding program in place using solely AI and purchasing high quality cows when required. The cows were fed 6-8 kg of grain throughout the winter and some Lucerne silage. The milking herd consists of predominantly Friesians. A actively participate in farm discussion groups and have strong confidence in the dairy industry.

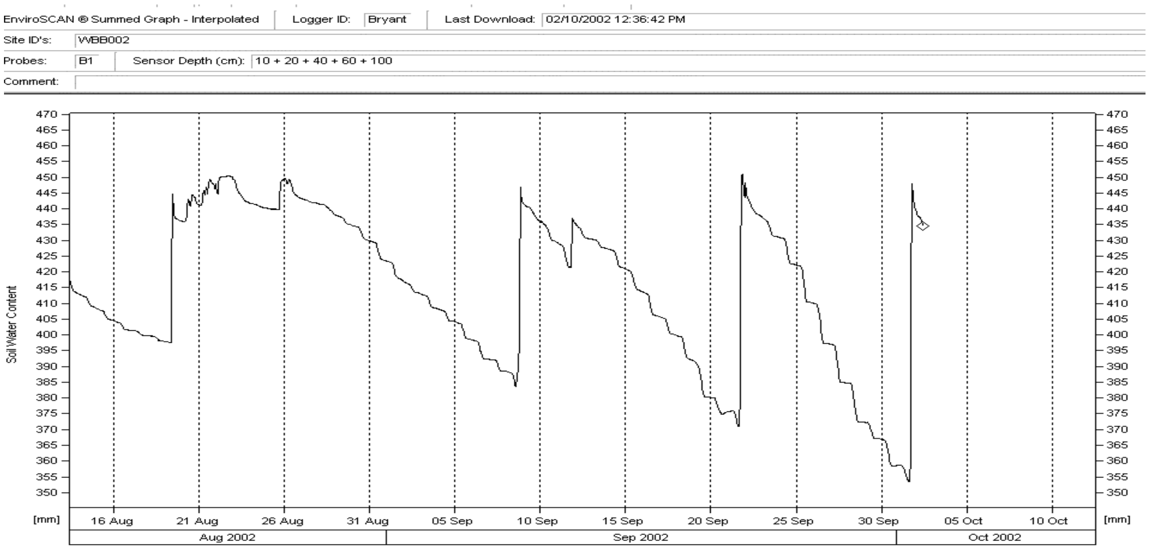
Irrigation profile

Farmer B –. See Enviroscan® graphs and automatic rain gauge chart attached The enviroscan graphs show that irrigation scheduling has been as close to crop requirements as possible, ensuring the soil moisture profile met crop demands. The predominant soil type near the enviroscan probe is clay loam.

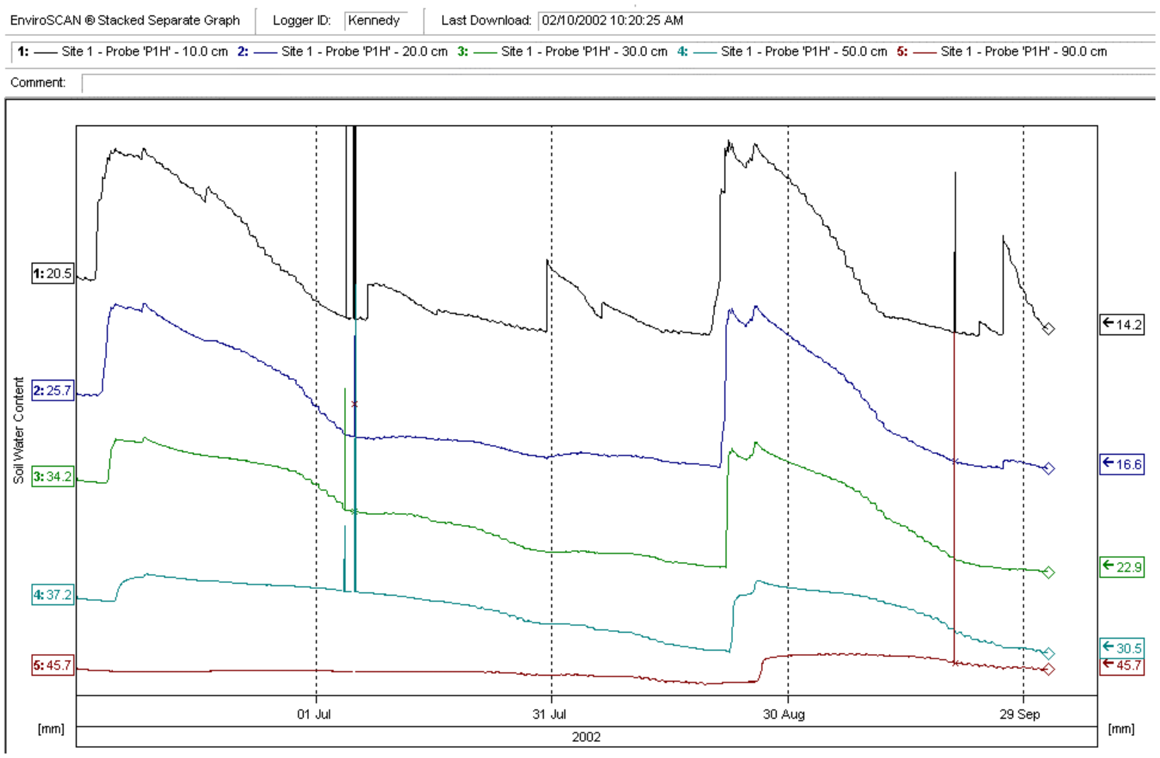


The enviroscan graph shows that the crop was essentially working down to the root depth of 40cm. Excellent irrigation scheduling practices are being followed with the ryegrass not having to extract moisture from deep in the soil profile.

The graph below demonstrates that the soil moisture content is being maintained within a reasonably constant range.

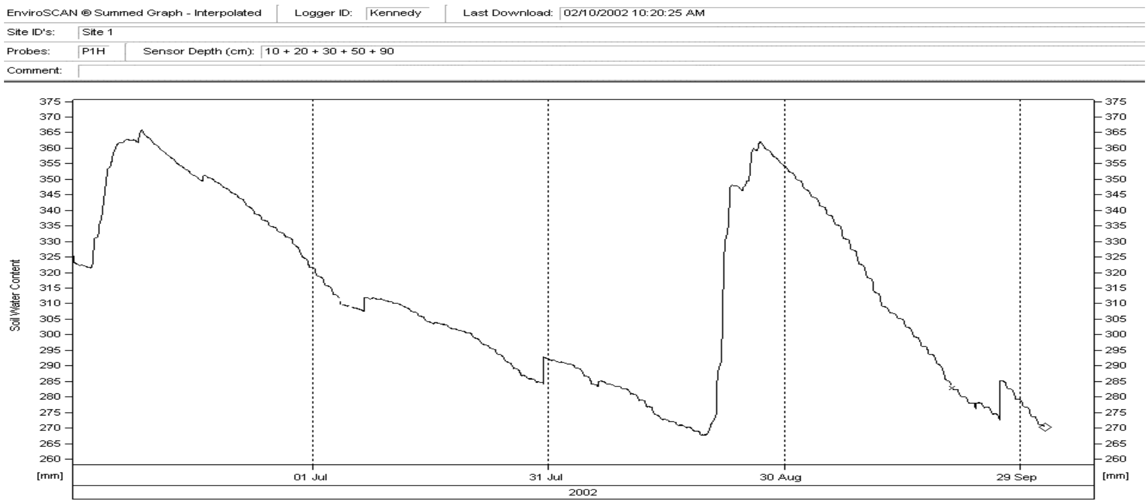


A – see enviroscan graphs and automatic rain gauge chart attached. The data shows that soil moisture was not as high as the crop demands. This would indicate that overall production may not have been as high as possible, however, cows produced in excess of 20 litres per day – The predominant soil type near the probes is sandy loam.



The enviroscan graph indicates an erratic irrigation pattern with the plants extracting moisture from down to 90cm. The ryegrass has been stressed on more than one occasion. The soil moisture content is being maintained at generally low levels.

The automatic logging rain gauge graph illustrates (page 27) the total rainfall and irrigation for the ryegrass period. B ryegrass received 409mm while A received 292mm.



Farmer Learning

Farmer B has gained a significant amount of knowledge from the RWUE project. B stated, " I thought I knew a lot about irrigation before being involved in the project, but I realize now that I knew nothing." The enviroscan has shown B that he needed to change his irrigation practices, which he did. B discovered that he was putting on twice the water that he actually required in certain instances, consequently wasting water and nutrients. With the change in practice he is managing to keep the fertilizer in the root zone of his pasture. He believes he has more than halved his electricity bill since changing his irrigation schedule. B has said that, "the RWUE project is one of the best things the government has done, the project should be kept going, it's continuation could yield enormous benefits." Even though the hand shift irrigation system is ancient it is still operating efficiently at above the industry benchmark of 80% DU. After having a full systems check he found out his pump is not working to it's maximum efficiency, operating at about 40%. He learnt that it is important to make correct pump selection before purchasing, efficiency levels and pumping costs can be greatly affected if the wrong choice is made.
B has changed his irrigation practices as a direct result of being a RWUE demonstration site.

Farmer A – an Enviroscan® and automatic rain gauge have only been installed since Autumn 2002. The A erected a centre pivot irrigator in April 2002 receiving the full rebate from the project's FIS. Unfortunately, they haven't been able to fully capitalize on the new irrigator or the information provided from the enviroscan due to water limitations. Even with the adverse conditions, based on the early enviroscan information A has changed his irrigation management under the pivot. He has discovered that he was under watering, but as explained could not water to the optimum level due to low dam levels. Having completed a second water storage this August, once a wet season develops the dams will fill and the irrigation system will be able to be used to its' maximum potential. The benefits of the pivot are already coming into effect. A has commented on the reduced labour input required to operate the machine and also the low level of repairs and maintenance compared with the travelling irrigators. A has commented that the ability to apply small amounts of water often during ryegrass establishment benefited the pasture production.

Results profile

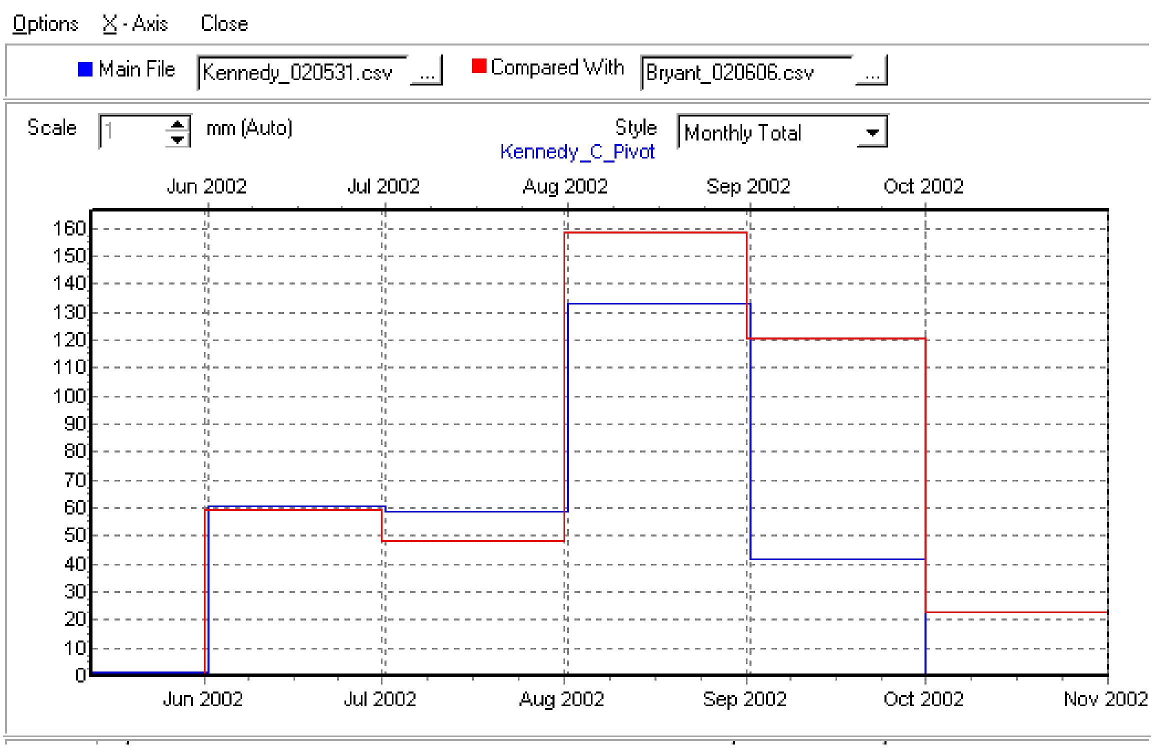
Throughout the ryegrass season each farm participated in a trial, which is yet to be completed. Using the 'Grassmaster' pasture measurements were taken on both pre and post grazed paddocks to assess the amount of pasture consumed. Milk production, fertilizer applications, supplementation and water applications were also measured.

The following figures are a selection spread across the August and early September period.

B – the results indicated that B cows were utilizing 977 kg DM/ha of ryegrass. They were receiving no grain supplement; the only additional feed was 0.9 kg DM of molasses per day. Assuming 1kg of milk from 1kg DM his cows yielded 9.1 litres per cow from pasture. Unfortunately his fertilizer program was reduced during this period and he applied 32 kg N/ha every second grazing.

A – the data collected from the A farm was significantly different with 1354 kg DM/ha utilized from ryegrass pasture. This resulted in 16.3 litres of milk per cow per day from pasture, given that they were also receiving 7.2 kg DM/d in grain supplementation. They (A) applied approximately 50 kg N /ha after each grazing.

Automatic Rainfall logger Graph



Discussion

Looking at the enviroscan and rain gauge charts alone would lead to the conclusion that B are the most efficient irrigators and perhaps they are, however, A grew much more pasture and made significantly more money. A ryegrass under the pivot was stressed at various times. They were simply unable to irrigate to the crops demands due to water shortages. B ryegrass received a total of 409mm while A received 292mm from June to October. Neither farmer wasted water; in fact A applied too little in order to achieve maximum production. This demonstrates that there is more to a farming system than irrigation alone.

Maintaining a continual fertilizer program throughout the ryegrass season is imperative. As seen on B farm fertilizer was not applied after each grazing and at an infrequent time period. This being a factor limited pasture growth even though irrigation was adequate. A said, “if I am going to the trouble of putting water on the pasture I might as well put fertilizer on.” Traditional recommendations of applying fertilizer after each grazing or according to soil tests have proven to be correct in this instance.

The supplementation program varied significantly between the farms. As indicated A received 7.2 kg DM/d of grain while B were fed 0.9 kg DM/d of molasses. The varied rations and corresponding milk production indicates that A cows were being fed well above maintenance requirements, while the majority of B fodder was going towards ensuring the basic function the cows. All cows need a certain level of feed just to function; additional fodder to this requirement is where the production comes from. Both farmers have to spend roughly the same amount to maintain their cows; milk yield above this is profit, bearing in mind the expenses associated. The cow condition between the herds also differed. Generally, the cows at A farm had a higher body condition score than B. When the feed was increased to B cows, rather than being converted totally to extra milk, some went onto the cows back.

Another factor that is considerably different between the two operations is the genetic merit of the cows. A pay particular attention to breeding and purchasing cows of a high genetic capacity. It is difficult to attribute specific milk yields to this factor, however, the literature indicates that cows bred for high production consistently out perform those that aren’t.

The results clearly demonstrate that producing milk is a complex business. Production does not only rely on efficient irrigation, as demonstrated in this case study, but on whole farm management. Factors such as fertilizer application, grain feeding and animal genetic merit are clearly crucial factors in the milk production system. Through adjusting irrigation schedules and managing other critical factors a profitable, sustainable dairy operation can be maintained.

Fertigation at Eungella

Greg Stanley, Bundaberg

Introduction

Part of the funding set aside under the “Irrigation for Profit” project was to undertake district projects that best suited the needs of the local producers.

In Central Queensland there are four districts of operation - Mackay, Rockhampton, Monto and Bundaberg/Biggenden, of which each has it’s own defined objectives within the project.

A meeting of Mackay producers indicated that they were very keen to investigate the use of fertigation equipment for the application of fertiliser on farm. This system is promoted as a water use efficient and labour saving management option.

While most producers had knowledge of such equipment their information on the latest units available was limited.

A property at Eungella, near Mackay, was chosen to install and demonstrate the fertigation equipment. They are recognised in the district as progressive and reliable co-operators.

Dowden’s Pumping of Mackay installed the system in April 2002 at a cost of **$2904.00.**
Included in the cost was an injection pump to inject fertiliser into the irrigation pipe, a fertiliser mixing tank – 350 litres, suitable for a 24 hour irrigation run and plus installation and electrical costs.

The Co-operator Learning’s

Seasonal conditions, namely the drought, contributed to the way the co-operator managed their irrigation system this year.

The co-operator said “Low water levels and the importance of conserving water saw us use the system sparingly during the year”.

Previously, when rain was about they would broadcast fertiliser with the spreader to save water. This would give a big boost of feed for a short time, not ideal management conditions for dairying.

But with the fertigation system he said “You put on a small amount of fertiliser after each grazing, keeping the rye at optimum growth levels, taking away the quick boosts of feed when using the spreader.

He also felt that, as Eungella is normally in a high rainfall area that you may not get the full benefit of the fertigation system compared with a farm in a lower rainfall area that needs to irrigate full time***. “ We fertilise when it looks like rain” he said.*** Production did improve when using the fertigation system in that the herd were getting access to good quality feed at optimum growth levels all the time.

Outcomes

While the fertigation project did run into some dry times in 2002, three important points did emerge:

1. **The system is labour saving.**
2. **It is simple and economical to install.**
3. **It produces more even feed at optimum growth levels more regularly.**

The early months, after installation of the fertigation system, were mainly used to fine-tune and gain practical experience in the use the equipment.

The fine-tuning resulted in the replacement of the original 80 litre rectangular tank for mixing fertiliser to the larger 350-litre tank. This was enough for the 24 hour run.

The recommendation by the manufacturer for the mixing of fertiliser and water was 50 kg Urea to 100 litres of water.

The unit allows the user to set percentages for the amount of fertiliser applied to pasture or crop.

They used 60 kg Urea in the 350-litre tank. The system applied 13.75 litres per hour over the 24 hour run with 20 litres left in the tank. The 24-hour run watered one hectare.


Set-up of fertigation equipment displaying pump and fertiliser mixing tank

Irrigation Audit Result Summary

Before commencing the project an audit of the property's irrigation system was carried out. They used a Southern Cross Traveller with 1.5 inch hose.

There was a big pressure loss in the 1.5 inch hose, accounting for about 60 psi pressure loss which would cost around $21.00 per ML.

Good distribution uniformity of 86.50% and a precipitation rate of 6 mm per hour were measured.

Conclusions

A workshop was held on the property on the 20th August 2002. The day consisted of the demonstration of the fertigation system followed by discussion by all stakeholders of the pros and cons of the system.

Also on the program was a presentation highlighting the importance of irrigation pump efficiency.

The simplicity of the system and labour savings were clear winners with the producers that attended the workshop.

Even though the drought curtailed the project to some extent, the positive feed back from the co-operators clearly indicated the systems usefulness in some irrigation systems.

Dairy - Case Study

South East Queensland, Che Murray

Summary

- **"We thought our travelling gun would be naturally more uniform"**
- **Enviroscan® interpretation needs years of experience**
- **"Download regularly to assess what you actually need"**

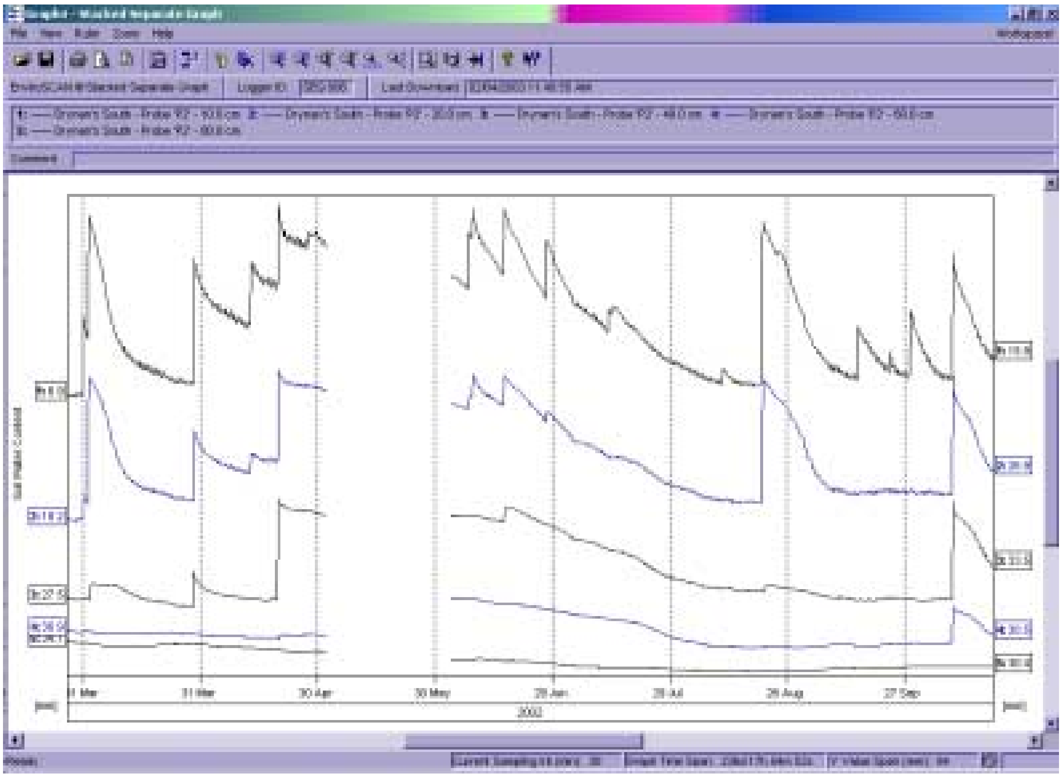
Background

The cooperative dairy farmer is based in the Innisplain region, south of Beaudesert. The farmer supplies milk to Pauls. The family milk around 105 cows on 22 hectares of irrigated rye grass. The farmer does not have any plans to expand his operation, at the moment he is focused on surviving the last two years which were both recorded as 1 in 25 year droughts. The farm is situated on the Logan River and in 2002 their water allocation was 20 megalitres (reduced by 40% from previous years). The farmer uses a Trailco T250 soft hose travelling gun to irrigate.

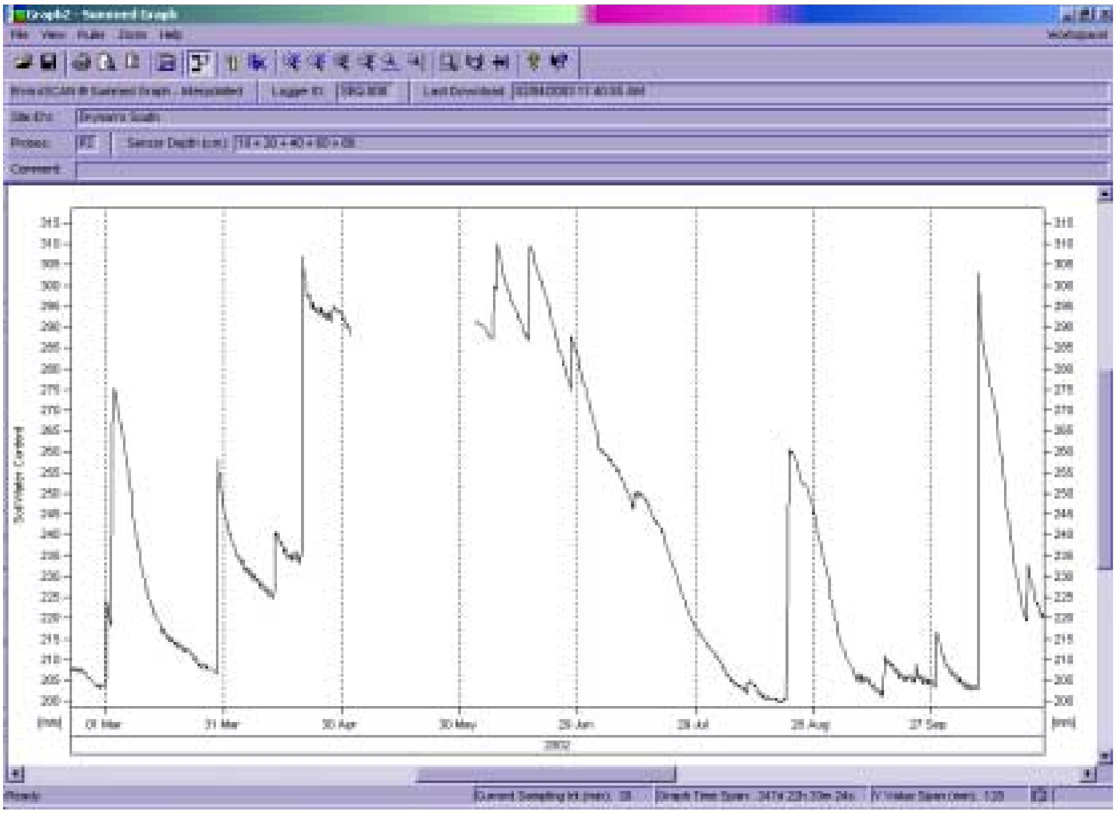
The farmer has been using an Enviroscan®, supplied by the project, to assist with water management; and the site also has a logable rain gauge. During the ryegrass season of 2002, pasture measurements have been taken before and after grazing of the paddocks with the Enviroscan® probes. During 2001 & 2002 the farmer has experienced severe water shortages. This has limited pasture growth and corresponding production. Cows were regularly fed about four kilograms of grain to supplement their diet.

Irrigation profile

See graphs below. The Enviroscan® graphs show that irrigation scheduling has been sporadic, which is a result of the farmer having to irrigate when he has the water, not when it is the best time to irrigate. The data shows that soil moisture was not as high as the crop demands.

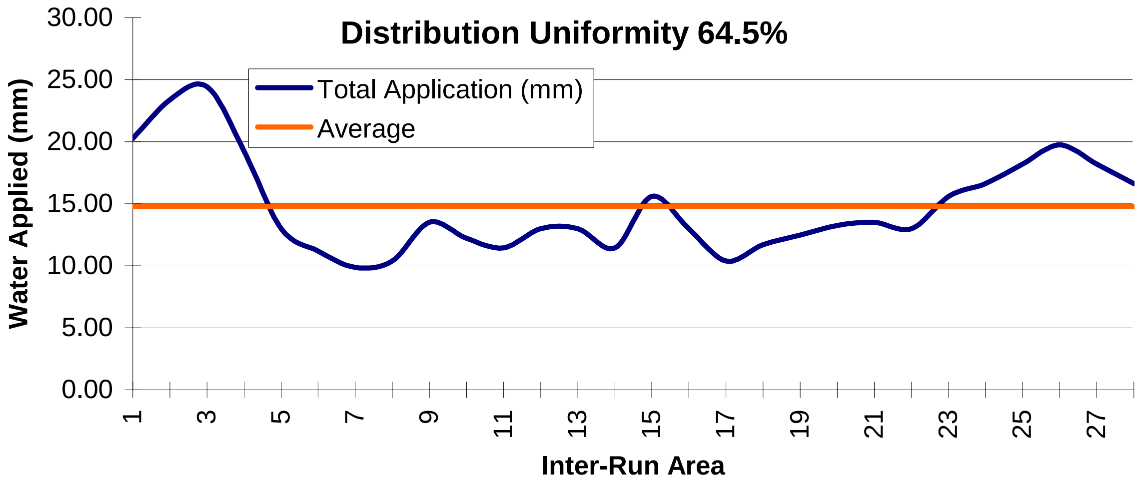


The Enviroscan® graph indicates that the soil moisture content is being maintained at generally low levels particularly in the top 10cm.



Farmer Learning's

The farmer has learnt a lot on different aspects of irrigation since his involvement with the RWUE project. Originally he assumed that travelling gun irrigators naturally applied water evenly. He also thought that setting up the lane spacings according to manufacturers specifications would guarantee the water was applied evenly. However, after an irrigation system check he discovered that his system was not applying water as well as it should be. The irrigator was found to be running at 64.5% Distribution Uniformity.



As can be seen the walker jets were applying a lot of water close to the irrigator carriage, however the rest of the paddock was receiving less than the average water application. Unfortunately due to financial restrictions and the impact of the drought, the farmer was unable to make any significant changes to the irrigation system. He did state "my neighbours crop is not growing evenly because the lane spacings are too far apart. You can actually see a wave effect across the paddock. This has become even more pronounced this season due to the effect of the drought".

In regards to downloading and interpreting the Enviroscan® data, the farmer has also learnt a great deal. "It is important to regularly download. You need to look at the data 3-4 days leading up to irrigation and then straight after to see what has happened in the soil profile. You need to be able to assess what you actually need".

The farmer did state that he found it frustrating removing the logger to download at his computer and then needing to return it afterwards. Unfortunately the Enviroscan® is not located in a suitable mobile phone reception location so he is unable to download the Enviroscan® using remote technology.
The farmer also highlighted the fact that "farmers are not technical on computers". Farmers involved in these types of trials need to be encouraged and assisted in using the software frequently. This is a fact that should be highlighted for any future projects involving computer software.

One of the main points to come from this demonstration farm was his observation that the Enviroscan® indicated that he should irrigate, however he simply did not have the water resources to do so. "With scarce water allocations we need to decide if we should reduce our irrigated area and water it properly, or keep the same area and hope it rains". This is the question currently facing many dairy farmers, and other irrigated farmers across the state.

The farmer also believes that you need years of experience using the Enviroscan® to be able to determine the amount of water to apply. "There is still a lot of trial and error work trying to correlate a rise in the graph with the millimetres to apply".

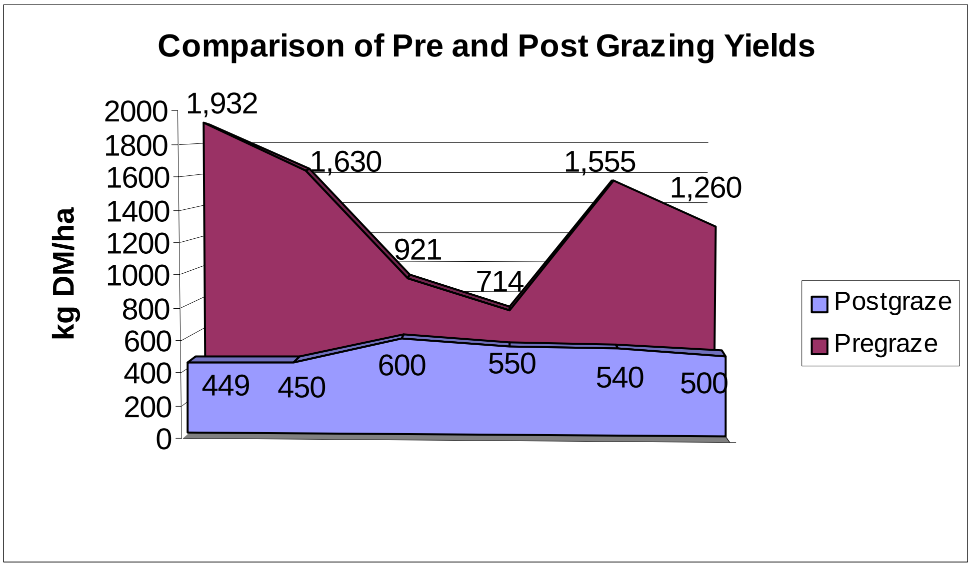
Pasture Yield Results

Throughout the 2002 ryegrass season the farm participated in a pasture production trial. Using the 'Grassmaster' pasture measurements were taken on both pre and post grazed paddocks to assess the amount of pasture consumed. Milk production, fertilizer applications, supplementation and water applications were also measured.

The cows were receiving approximately 4kg of grain supplement, as well as night pasture paddocks (mixed pasture of Lucerne, clover and chicory). Assuming 1kg of milk from 1kg DM his cows yielded 7.3 litres per cow from pasture. He was also using approximately 5.37ML/ha to produce 5,110 kg DM/ha in the rye grass paddocks.

Figure 1 demonstrates the pre and post grazing pasture yields on the farm. These results are from the two paddocks which were monitored by the Enviroscan® probes.

Figure 1



Conclusion

The cooperative farmer found the Enviroscan® to be a beneficial tool when scheduling irrigation. "At the start of the project I realised I didn't know a lot of things about irrigation, which I should have known". While the Enviroscan® has been valuable in determining when to irrigate, water restrictions hampered the full benefit the farmer could have gained from fully scheduling his irrigations. "The Enviroscan® made us aware of when we should irrigate, but due to restrictions we were unable to alter our irrigation schedule".

For the full benefit of the project and the use of Enviroscans® to be realised, these demonstration sites need to continue over a number of years. This allows the farmers to better compare what is happening on paddocks to what the graphs are demonstrating, and also allow for different climatic conditions.

Dairy Farmer – Hand shift/Travelling Boom
Biddeston

Tim Biggs, Toowoomba

- ✓ **Different soil types require different amounts of water applied to maintain optimum readily available water.**
- ✓ **Soil moisture monitoring tools helps with irrigation strategies for increased germination and to prevent waterlogging.**
- ✓ **'I always put a bit more water on to make sure the plants would not stress, I didn't realise I was stressing the plant from over-irrigation'.**

Summary

This site was set up to look at the effect of irrigation on different soil types and how it could be managed. The farmer uses a travelling boom and spraylines. During times of drought, the levels of the bores drop and cause problems when using the travelling boom. In this situation the farmer uses the boom to apply a light initial irrigation after the pasture has been sown, and then goes on to apply subsequent irrigations by spraylines.

The farm is situated in the Biddeston area about 30km west of Toowoomba. The irrigation area where the probes are installed on the farm consists of 36 hectares of heavy black clay and a lighter red clay loam.

The stocking rate for the farm is 4.3 cows/irrigated ha producing 6726 litres milk/ha irrigated pasture. This can be further broken down to 2069 litres milk/ML irrigation as there are 3.3 ML/ha of water used for irrigation.

The farmer had been involved in the Rural Water Use Efficiency Initiative from very early on. His irrigation system was used in a case study for the Initiative Audit at the start of the project. He also showed a strong interest in being involved in a trial site as well as being part of an ongoing discussion group. EnviroSCAN® data was presented to the discussion group to show how scheduling tools can be beneficial to irrigation management.

Two EnviroSCAN® probes were initially installed in a lucerne paddock in December 2000. Unfortunately there was only access to an older unit with probes that only went down to 70cms. Ideally probes should have had been down to 100cms for lucerne. Unlike a number of the older EnviroSCAN® units that were around at the time, this unit worked well throughout the 5 months that it was installed. The sensors were set at 10cms, 20cms, 40cms and 70cms on both probes, which were then placed in adjacent irrigated runs in different soil types.

Scheduling Tools
EnviroSCAN® from Sentek were used at this farm. As indicated before, the probes were of an older model initially but performed well enough. The sensors were set at 10cms, 20cms, 40cms and 70cms on both probes, which were then placed in adjacent irrigated runs in different soil types. The EnviroSCAN® was replaced with an updated version in late June 2001 and the probe was calibrated with sensors at 10cms, 20cms, 40cms, 60cms, and 100cms.

Outcomes

The heavier black soil appeared to show a much lower moisture holding capacity than the lighter reddish soil over the whole profile. Significant changes in soil moisture at the 100cm sensor in the heavier soil were recorded after all irrigation events and most rainfall events. Changes at the 100cm sensor in the lighter soil were only noticeable after an irrigation event or heavier rainfall event. These changes only showed a minimal rise in moisture levels.

A closer look at the stacked graphs actually showed that the lucerne was unable to extract large amounts of moisture from the heavier soil particles (Diagrams 1). Once the lucerne had extracted a certain amount of moisture from 10cms it appeared that extracting moisture from 20cms was preferable to continued extraction at the 10cm level. Heavy clay soils have a lower level of readily available water (RAW) as the clay particles bind strongly to water molecules. It therefore makes sense for a plant to extract moisture from lower in the profile where the RAW has not been depleted, rather than waste energy trying to draw moisture from the drier profile above.

The minimal change at the 100cm profile in the lighter reddish soil was most likely due to the fact that the lucerne was able to extract adequate moisture from the soil profile above (Diagram 2). Readily available water (RAW) accounts for a much higher percentage of plant available water (PAW) in lighter soils.

The irrigation applications at this site greatly exceeded the refill requirements of both soil types. Waterlogging occurred after some irrigation events. Likewise irrigation did not occur at refill point, but well after the onset of stress. Due to the implications of readily available water (RAW) the heavier soil reached the refill point long before the lighter soil, and thus the lucerne in the heavy clay remained in a stressed state for several days longer than the lucerne in the lighter soil.

Due to a lack of irrigation infrastructure at this site the farmer would partially plan his irrigation on a fixed rotation of spraylines. This tends to lead to plant stress due to lack of soil moisture. Another classic irrigation pattern in dairy farms is to irrigate a paddock straight after grazing has occurred regardless of whether refill point has been reached or not.

There were a couple of options available for improving irrigation scheduling on this farm. One was to reduce the total area of irrigation so proper scheduling was possible. The second was to increase the irrigation infrastructure and continue irrigating the same area. Using the Rural Water Use Efficiency Initiative's Financial Incentive Scheme the farmer chose to increase the number of spraylines and upgrade existing sprinklers to achieve greater uniformity. The increase in spraylines not only allowed him to concentrate on nighttime irrigation, but also made it much easier to apply smaller amounts of irrigation more frequently and hence combat periods of waterlogging and plant stress.

EnviroSCAN® data for the 2002 winter season showed irrigation scheduling to be much improved. The probes were set up with sensors at 10cms, 20cms, 40cms, 60cms and 100cms. As this was a ryegrass/clover pasture there would normally be no need for the 100cm sensor, but due to the previous year's findings with over irrigation we decided to monitor any deep drainage. The probes were placed in the same irrigation run with one in a heavier clay soil and one in the lighter reddish soil. The previous probes had been in adjacent runs so it had been harder to compare the effects of irrigation in different soil types as the two runs were irrigated at different times.

Soil moisture remained between the full point and refill point in the lighter soil and only went below the refill point on a couple of occasions in the heavier soil. This meant that the farmer would have, due to the smaller applications applied, a reduced chance of waterlogging during the season. During the winter season evapo-transpiration rates are lower so soil moisture does not reach refill point as quickly. This may account for the reduced levels of stress reached by the pasture, however the changed scheduling pattern due to the reliance on the EnviroSCAN® data was a major contributing factor.

A couple of interesting observations were noticed over time. The profile of the heavier soil appeared to be holding a lower percentage of moisture than the lighter soil despite receiving the same amount of irrigation at the same time. Secondly, the plants in the heavier soil were not drawing any moisture from the 60cm profile or below whilst the plants in the lighter soil were drawing moisture from at least 80cms. Without a soil test it is hard to work out a reason for these occurrences.

When considering irrigation management practices on different soil types a couple of steps can be taken. If different soil types are confined to different paddocks then precipitation rates and application amounts can be adjusted. In many cases soil changes will occur within an irrigation run. If the changes are extreme then nozzle sizes on spraylines can be altered, however this is time consuming.

In the case of this site, irrigation was applied to try and suit both soil types during the 2002 winter season. This meant avoiding extreme cases of waterlogging or periods of stress. It is better to slightly over irrigate one area of soil and avoid moisture stress in another rather than match irrigation to a soil type and allow the other soil type to become extremely low in moisture.

By looking at the irrigation management of this site between late 2000 and mid 2002 the changes have been promising. Water is now being used more efficiently with the farmer showing a greater awareness. Although no pasture cuts were taken, production has remained at a fairly similar rate, but with the use of less water even through times of drought. The reduced periods of moisture stress have allowed regrowth to occur more rapidly, and fewer waterlogging events have stopped stalling the growth rates after irrigation. Irrigation management is running more efficiently on the farm, particularly due to the addition of new spraylines, extra knowledge and understanding gained from having a system check performed.

In October 2002 the EnviroSCAN® probes were shifted to a new site on the farm. The new site is predominately red soil with lucerne planted into it. Due to the adverse season and lack of water, the farmer only irrigated half the paddock with the travelling boom. The results for the EnviroSCAN® show that the soils are slowly drying out. The farmer is currently restricted by the number of hours he can irrigate. This makes it difficult to achieve adequate production levels from both his milk and pasture.

Learning's

An important issue that has been resolved at the trial site is the amount of water the farmer needed to complete his irrigation. This has been achieved with the use of the EnviroSCAN® soil moisture-monitoring probe. The farmer said he was pleased with the outcomes of the EnviroSCAN® scheduling tool as it helped him to understand the problems that occur with waterlogging. Prior to the installation of the EnviroSCAN®, there was a tendency to over irrigate to ensure that there was enough water put across the crop. The EnviroSCAN® provided accurate data showing how much water was moving through the soil profile and how much water was being taken up in the root zone. The farmer indicated that he was not that surprised to see that he was using too much water.

Another benefit that the farmer said he received was a better irrigation strategy to help germination and subsequent irrigations after the soil profile has been irrigated to refill point. The farmer said that using the moisture monitoring tools has enabled him to reduce the amount of water used during an irrigation event substantially and this has helped increase production on the farm.

System Check

A system check was performed in January 2001. The results of the sprayline Distribution of Uniformity check can be seen in Diagram 5. The overall Distribution Uniformity was low (55%) but some of this can be accounted to the weather conditions on the day of the check. Wind speeds ranged from 6km/h to 19km/h causing an uneven pattern to appear. To over come this problem and ensure that all surfaces areas were irrigated the farmer would have to shorten his distance between shifts. There were pressure variations of up to 15psi (103Kpa) along the pipeline. This coupled with variations in nozzle sizes, makes it difficult to achieve the 75-85% DU required of a system like this

Diagram 1 Stacked Graph; Heavier Black Soil - Lucerne

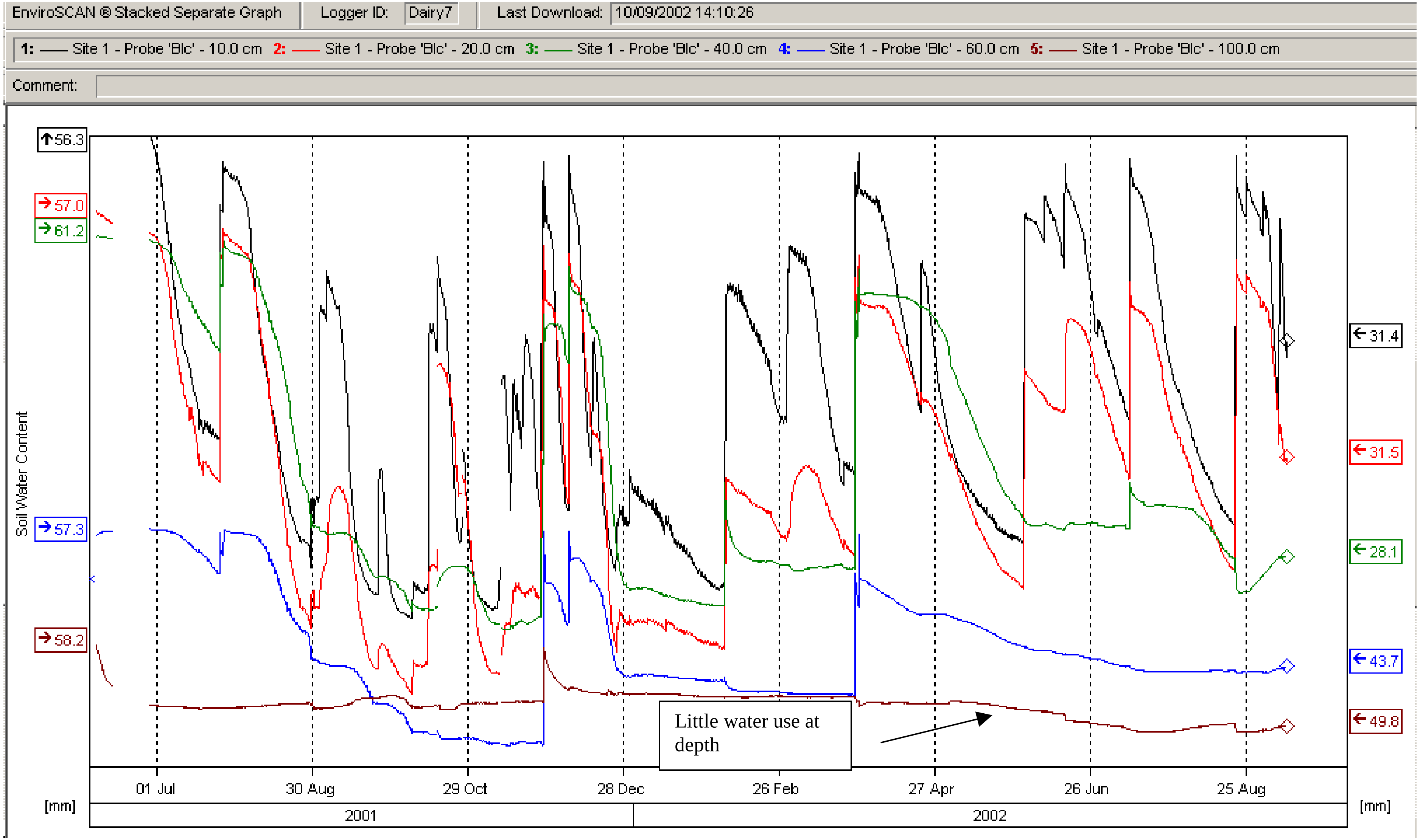


Diagram 2 Stacked Graph; Lighter Red Soil - Lucerne

Diagram 3 Summer Graph; Both Sites

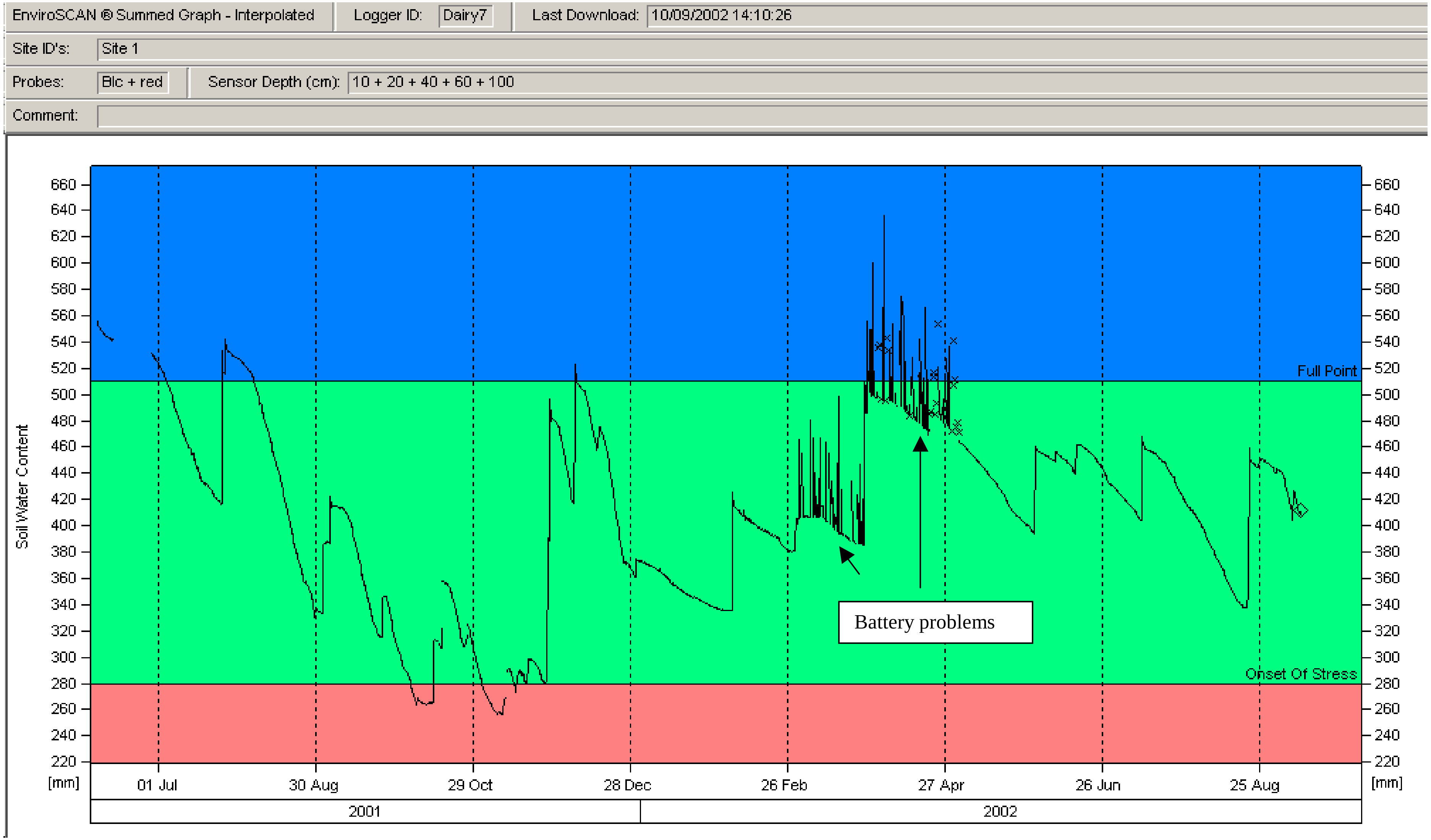


Diagram 4 Summed Graph; Light Red Soil – Lucerne (part 2 of trial)

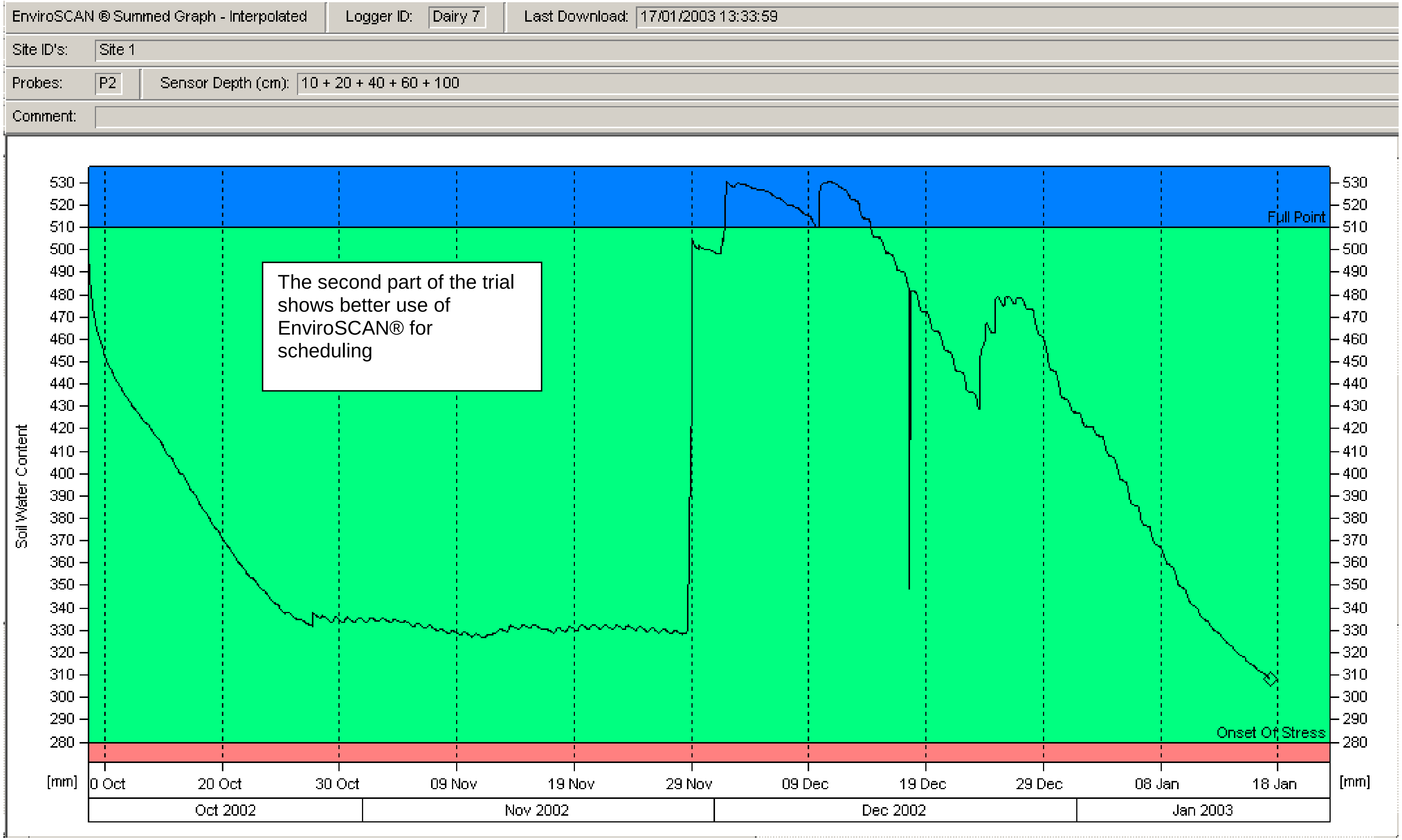
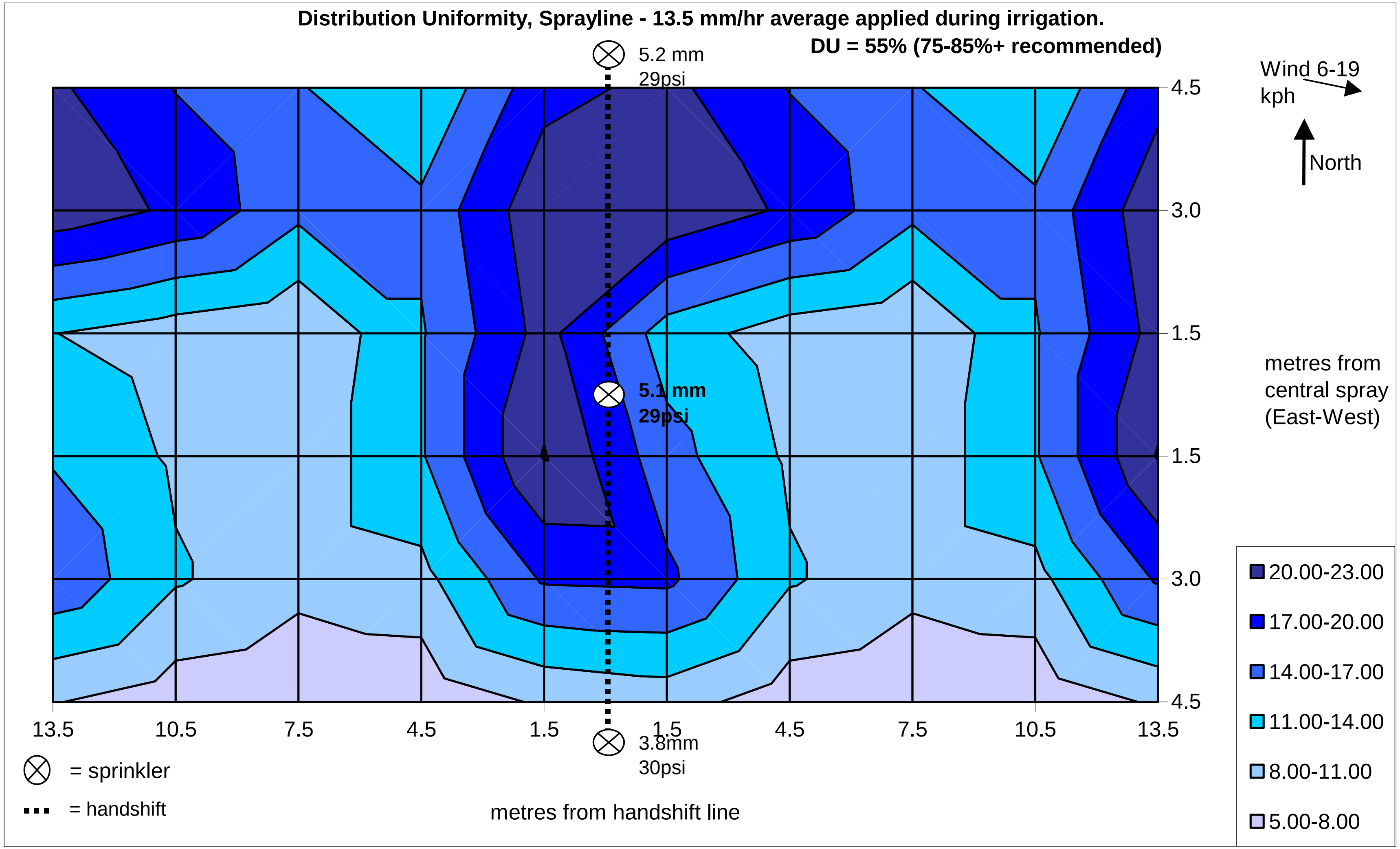


Diagram 5 Distribution Uniformity Graph for Handshift System



Sprinklers need attention

Dairy Farm – Centre Pivot/Scheduling
Westbrook

Tim Biggs, Toowoomba

- ✓ **Water logging had been a factor in reducing crop yields by irrigating too soon after rain. The water levels in the soil profile were still at the upper levels when the farmer was irrigating.**

- ✓ **With the introduction of soil moisture monitoring tools the farmer found he was better able to manage his irrigation schedules.**

- ✓ **With the aid of the EnviroSCAN®® the farmer has been able to conduct self-driven trials.**

Summary

One of the primary reasons for a trial site at this farm was due to the presence of a centre pivot. Centre pivots are often looked upon as a fairly advanced form of irrigation so this provided an interesting site. There are very few dairy farms on the Darling Downs using centre pivots so this created a second opportunity for farmers to become aware of this type of irrigation. The farmers also use a travelling boom for irrigation so there was the flexibility of comparing scheduling tools under 2 different types of irrigation.

The farm is situated in the Westbrook district about 20km southwest of Toowoomba. The EnviroSCAN® probes were set up in two paddocks under a centre pivot irrigation system. One paddock is an area 7ha that the pivot covers in a half circle. The second paddock is a 14.5ha area that the pivot covers in a full circle. The pivot only contains four spans and is towed between the two paddocks. The two different paddocks are usually only farmed seasonally for different crops and pastures

The total farm area available to irrigation would exceed the water allocation if irrigated all year round. The farmer's attitude towards keeping within his allocation and the importance he placed upon maintaining his bores was very impressive. He also had a strong interest in using his available water efficiently but admitted to a lack of knowledge where precision scheduling was concerned.

After discussions with the farmer it became clear that a trial site would be mutually beneficial, however he did raise concerns about being placed in the spotlight. It was agreed that the RWUEI could use results and information anonymously on a wider

scale, but his local discussion group and local farms would be involved with the trial site if they wished.

It was decided to use the EnviroSCAN® on this site, as it would provide continuous soil moisture monitoring. The farmer was interested in being involved in the downloading and interpretation of the data so we put the software onto his computer. The focus of this site was to look at the effectiveness and ease of use of the EnviroSCAN® from the farmer's point of view. Initially one probe was installed with four sensors on it at 10cm, 30cm, 60cm and 100cm in lucerne on the half-circle site. The farmer also borrowed and installed a water meter for a short while in order to gain an accurate pumping rate.

Scheduling Tools

The main soil moisture-monitoring tool used on this farm was the EnviroSCAN® from Sentek. The EnviroSCAN® is a continuous soil moisture monitoring system that uses the dielectric constant of the soil to produce highly accurate moisture recordings. Sampling can be set as often as every minute through to every 7 days between readings. Multiple sensors attached to probes are placed inside access tubes, which are positioned in the ground. The sensors are mounted one above the other with up to two runs of 16 sensors attached to the probe. Power is obtained in the form of a solar panel and a storage battery. Data may be downloaded at the logger using a laptop, or the logger may be taken to the PC. Remote downloading is possible through mobiles, modems, landlines and high or low frequency radios

Outcomes

Trial 1

The first two months of data (mid-Dec 2000 to mid-Feb 2001) were quite informative for the farmer (Diagram 1). If the EnviroSCAN® data had already been showing a full point and refill point pattern his management decisions would have been different. After a pattern had been established by mid-January it became clear that the first irrigation after the installation in December could have been delayed for about 10 days. Although at the time of the first irrigation we knew rain was forecast, the farmer decided to go ahead with an irrigation to avoid stressing the lucerne. What was not known was the lucerne actually still had adequate soil moisture for approximately 10 days. Seven days after the irrigation the lucerne received 70mm of rain. The soil was already waterlogged when it rained, and this addition to the soil moisture meant that the lucerne was in a waterlogged state, and hence showed minimum growth, for 14 days.

Twelve days after the 70mm rainfall a second fall of 20mm occurred. A further 8 days after this rainfall the soil profile reached refill point. Again rainfall was forecast and the farmer having seen the effect of waterlogging on the growth of his lucerne decided to hold off irrigating for a couple of days. A 98mm rainfall rewarded his management plan two days later. The rain filled the profile and waterlogging only occurred for 3 days. By working with the EnviroSCAN® data the farmer actually saved 1.74 ML (25mm over 7 ha) and avoided somewhere between 8 to 12 days of waterlogging where lucerne growth would have been severely impeded.

The stacked EnviroSCAN® graph clearly showed that there was no root activity at the 100cm sensor, and virtually no movement in the moisture level after rainfall or irrigation events. The conclusion was that there was either some physical barrier stopping water movement or root development, for example an iron-pan or a pH problem, or at the 100cm profile the soil was constantly at full point and therefore deep drainage was not registering on the EnviroSCAN® graph. An effective way to further investigate this problem would have been an analysis of a 1-metre soil core, however this was not done. The 100cm sensor was later moved up to 80cms where both root activity and changing soil moisture levels were apparent.

The information in this first trial gave the farmer valuable insight in how water moves through the soil profile from irrigation events and uptake from plant roots. This provided the necessary information to set up the second trial.

Trial 2
In June 2001 a second trial was started. Sensors were set at 10cm, 30cm, 60cm and 80cm in a barley crop under the full-circle site. A tipping bucket rain gauge was placed fairly close to the probe so accurate irrigation and rainfall events could be measured at that location. With the data generated we were able to work out dry matter production per megalitre for barley silage. The results are shown below.

Barley Silage

Date Sown	20-May-01
Area Sown (ha)	14.57
Moisture in profile on date of sowing	Full
Total Irrigation (mm)	128
Total Rain (mm)	37
Date Cut	26-Sep-01
Moisture in profile on date of cutting	20 days beyond refill point
Total tons cut	260
Tons/ha	17.84
% Moisture	72
Dry matter/ha (ton)	4.996
Total water used	165 mm (rain & irrigation) + 75 mm (in profile at start) = 240 mm
Litres effective irrigation/kg dry matter	480

In this situation, 1 kg of barley silage dry matter was produced from 480 litres of effective irrigation. This equates to nearly 2.1 tons per megalitre and 2.4 megalitres per hectare.

The EnviroSCAN® graphs (Diagram 2) indicated that the soil moisture was kept very high throughout the majority of the growth season. There was potential for the time between irrigation events to be extended. This would possibly have saved some water and would have also avoided a state of saturation in the soil profile on a couple of occasions. As waterlogging reduces growth rates there is probably quite a bit of potential to produce more kgs of dry matter per megalitre applied. The use of long-term weather data in a situation such as this could be very beneficial.

Further calculations for 2001 made by the farmer using information from the EnviroSCAN® and water meter showed that 73 litres of effective irrigation produced 1 litre of milk (fresh cows) from winter clovers and 211 litres of effective irrigation produced 1 litre of milk from summer lucerne.

Learning's

The site has had some very successful outcomes and has created interest amongst the surrounding farms. On several occasions we have presented the findings to the Westbrook Discussion Group as well as demonstrating the effectiveness of using scheduling tools at a number of meetings and workshops around the Darling Downs. The farmer was the Irrigator of the Year for RWUE (Dairy) in 2000.

There have been a number of management changes due to learning's from the trial site. The farmer has become much more aware of irrigating to suit soil type and effective root depth. This has led to reduced applications per irrigation event and some significant water savings. The farmer has become much more aware of the implications of waterlogging and is very conscious to avoid such situations. Improved scheduling management has also come into play, with the farmer making better use of rainfall where possible.

One of the main problems that came across with the site was that although the farmer was able to download and interpret the EnviroSCAN® information he did not often find the time to do this. When he did manage to bring the logger up to his computer in the house he would forget to take the logger back to the EnviroSCAN® unit for a couple of days. Usually the only loss would be a few days data, although on one occasion the battery ran down in the logger which meant that no readings were taken for a couple of weeks as we were unaware of the problem. The majority of downloads were completed by a staff member and printed graphs were given to the farmer. If downloads had been made by the farmer prior to irrigating he may well have been able to improve his scheduling even more. In effect he was only working with half of the available information.

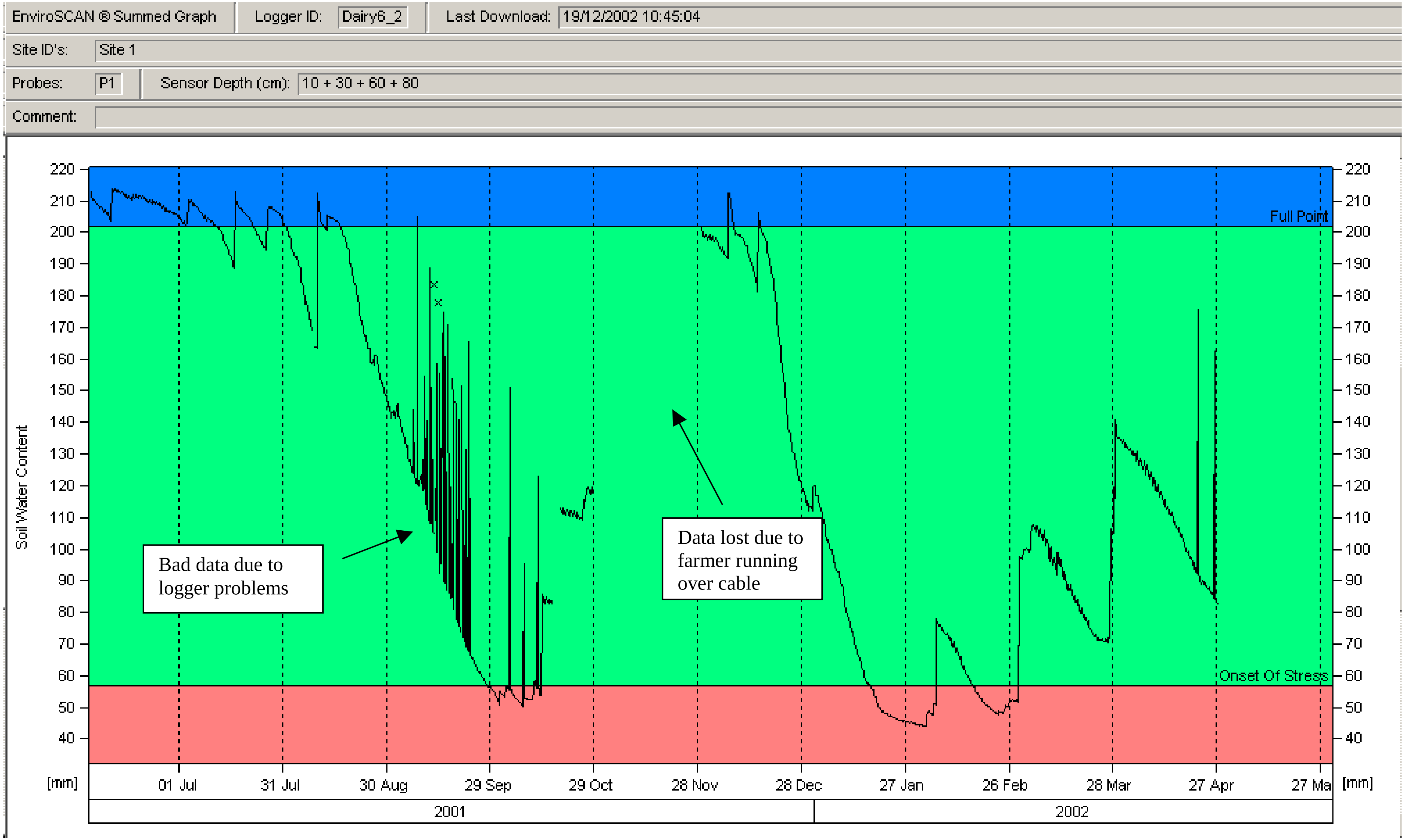
A second problem was created when the farmer accidentally pulled up some of the cable near a probe whilst ploughing. This was unfortunate as at that particular point the cable was a little too shallow. Repairs were done with no further problems occurring.

The farmer has been able to conduct his own trials using the EnviroSCAN® to test out different irrigation schedules and amounts. Recently he has been irrigating his lucerne under the centre pivot with 12.5mm every 3 days. This has not been a success as the EnviroSCAN® has shown that only the top 20cm of soil are getting moisture. The soil profile is slowly drying out at depth. The farmer then changed to a schedule of 25mm every 6 days. This enables the moisture to move down the soil profile and reach the bottom root zone. The farmer has also been able to make use of the knowledge from the RWUE staff to solve distribution uniformity problems with the centre pivot. Changing his sprinkler package from splash pads to spinners will help increase his DU%.

After a discussion with the farmer he felt that his involvement with the RWUE scheme has been valuable to his farm, but it has been difficult to identify if production has increased over time due to continuing drought conditions. He indicated that his milk production hadn't made any significant changes.

Diagram 1 Summed Graph for Trial 1

Diagram 2 Summed Graph for Trial 2


EnviroSCAN ® Summed Graph
Logger ID: Dairy6_2
Last Download: 19/12/2002 10:45:04
Site ID's: Site 1
Probes: P1
Sensor Depth (cm): 10 + 30 + 60 + 80
Comment:
Soil Water Content
[mm]
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
Full Point
Onset Of Stress
Bad data due to logger problems
Data lost due to farmer running over cable
01 Jul
31 Jul
30 Aug
29 Sep
29 Oct
28 Nov
28 Dec
27 Jan
26 Feb
28 Mar
27 Apr
27 Ma
2001
2002

Subsurface Drip Irrigation, Biloela
Ken Bullen, Gatton & Scott Wallace Toowoomba

Summary

- **"We were just wasting water using the hand shift system"**
- **Emitter flaps appear to be preventing root intrusion**
- **Sub-surface drip has different management issues compared to overhead systems**

Introduction

This demonstration grower is probably the most experienced farmer in the district with sub-surface drip irrigation (SDI).

Even with this amount of experience

"*They suspected that their 24-hour irrigation intervals might have been forcing water below the effective root zone and thus losing a valuable resource due to deep percolation".*

They have completed their own yield comparison testing between the two different irrigation systems on their property. Their records show that on similar soil types, a hand shift irrigator delivering a total of 432mm produced a similar hay yield to the SDI system delivering 271mm - an increase in Agronomic Efficiency of 63%.
This is more than enough reason to justify the extra expense of installing SDI.

She stated that, ***"We were just wasting the water using the hand shift system"*** (by 37%)

There are nevertheless some potential drawbacks with SDI. They cited

"*Root intrusion into micropores (drip tape emitters) and the use of drip tape which has flaps over the emitters appears to be preventing this"*

"High set-up cost" ($8000 to merely re-tape a 6ha block)

"Filter systems for SDI must be effective but are expensive"

"SDI systems are not transportable from the old Lucerne paddock to the new paddock - thus additional capital outlay is required for tape at least when new paddocks are planted"

Involvement

The farm has been a long established demonstration site for Department of Primary Industries and has been a focal point for the adoption of SDI in

Queensland agriculture, with over 500ha of Lucerne serviced by SDI in the Callide Valley.

Due to a chronic irrigation water shortage spanning many years the installation of SDI, the first for the area, has been of much interest among district Lucerne growers as a means of improving water use efficiency and reducing the volume of water pumped

The demonstration growers have participated in the holding of two (2) field days at their property.

The first field day was held on the 9th April 2001 and approximately 20 growers from the area participated. This day was an information day to let people know about the RWUE project activities in the area, the benefits of system checking, soil moisture monitoring, Financial Incentive Scheme and to give people more of an insight into the management of SDI.

A second field day was held in December 2001 as part of Tony Thomson’s, Irrigation Engineer from South Australia, visit to Queensland. Tony’s presentation develops grower awareness to relevant irrigation practices and the efficient use of irrigation to optimise yield/ML.

On this day Ian Bell, Manager- Rural Water Use Efficiency NR&M, was also there to present Trevor and Lyn Stringer the Irrigator of the Year award for 2001. The award was for management practices of irrigation water and agronomic production regardless of the type of irrigation system being utilized.

RWUE Activities

In the month of February 2001 RWUE staff installed an EnviroSCAN® soil-moisture monitoring unit into one of the SDI paddocks.

EnviroSCAN® is a moisture capacitance sensor probe and is capable of logging data on a continual basis.

The demonstration paddock is 6 ha and the SDI is positioned 300mm below the surface with 1.5 metre laterals and emitters every 300mm.

Three 1 metre soil moisture probes were installed to collect data from 50mm, 300mm and 750mm away from the SDI tape. The 1 metre probes measure moisture levels every 30 minutes and the sensors are positioned at depths of 100, 200, 300, 600, and 900 mm.

During the installation process it was noted that the soil was predominately light sandy clay and there was a distinct gravel layer at approximately 800 mm, of about 100 mm in depth.
EnviroSCAN® data collected showed ease of water movement and root development through the light soil.

The probe closest to the tape, 50mm, was indicating good moisture levels but there appeared to be irrigation water percolating past 1 metre during a 24-hour irrigation interval.
With data collected such as this, it was viewed that a certain quantity of water was needed to completely irrigate the soil between the two laterals and water was being lost to deep percolation. .

Because of grower suspicion and the results from the EnviroSCAN® about the loss of water to deep percolation, they requested that a 2.0 m EnviroSCAN® soil probe be installed.

This was installed on 30 August 2001. Sensor depths for this probe were positioned at 100, 300, 400, 1000, 1300, 1600, 2000 mm. It was noted that gravel layers of approximately 100 mm in depth were found at 800, 1200 and 1800 mm within the profile.

The deep probe revealed that irrigations of 12 hours duration were not resulting in percolation below 160 cm and that there was root activity also at this depth.
However, there was no trial of 24-hour irrigations to cross check the claim using the deep probe. In fact 24-hour irrigations ceased on 18/04/01.

Despite this request, and farmer keenness to cooperate on the Irrigation For Profit Project, they have not used the EnviroSCAN® installation in scheduling their irrigation. They have instead continued to use tensiometers for this purpose.

On the agreement of becoming a demonstration site for the RWUE project they were requested to provide yield per mega litre data for the paddock site of the EnviroSCAN®.

For the financial year of 2001 – 2002 the farm was able to produce 22.5 tonnes per hectare and use only 0.548 ML (mega litres) per tonne on the 6-hectare demonstration block. This is well below long term a respected production figure, for Lucerne, of 0.73 ML per tonne.

Efficiency Testing

The farming operation is spread over two adjoining properties along the Kariboe Creek and produces a range of crops - grapes, Lucerne hay, cereals and herbs for processing.

As part of system checking on demonstration sites pump checks were performed.

	Pump Efficiency %	**$ / ML**	**Delivery**
Sub-Surface Drip	53	23.07	1.67 mm/hr

Two pumps are required to provide enough water volume and pressure to operate the two hand shift spray-lines with a total of 82 sprinklers.

	Pump Efficiency %	**$ / ML**
Hand Shift 1	26	33.88
Hand Shift 2	33	31.81
Combined Figure		65.69
Benchmark	75	30 - 40

At the time of the test, January 15th 2002, both of these bore pumps were at their limit concerning water supply and were drawing air.

Side Roll Irrigator, Inglewood
Ken Bullen, Gatton & Scott Wallace Toowoomba

Summary

- **Confirmation that deep percolation was not occurring**

- **Poor DU which can be easily rectified and will improve yield dramatically**

- **Would be better able to meet crop water requirements with a reduction in irrigated area**

Introduction

The co-operative grower operates a mixed farming regime of irrigated Lucerne for hay and beef cattle. Lucerne is irrigated utilising three side-rolls. The farm demonstration site is an area of 20 hectare irrigated by two side-rolls, one-x 300 metres in length and the other is 600 metres in length.

One of the significant learning's for the family was that current irrigation practices were not causing deep percolation as was suspected. This was evident from results obtained via the 2-metre EnviroSCAN® probe.

Current financial data indicates that there may be potential to improve their Gross Margin by irrigating smaller areas with each side-roll

The grower commented, **"I believe that by reducing the irrigated area to 12ha compared to the current 20ha, we would be better able to cater for the peak irrigation demand of our Lucerne"**. *(Eg, in mid-summer, the main growing season)*

He is currently trialing the use of a soil aerator to improve infiltration and decrease ponding on the soil surface due to compaction.

The grower commented, ***" Initial results have been very good with no waterlogging occurring".***
EnviroSCAN® readings within the affected area are showing that there has been a significant decrease in the saturation of the top 20 cm of soil.

Initial system checks revealed minor problems with the pumping unit and an average Distribution Uniformity % (DU%) for the three side-rolls. Their immediate response was to test the pump to determine faults within the system.

He stated **"I found that two mating pipe flanges on the discharge side of the pump were misaligned and causing a restriction in flow. Once this**

was changed pump pressure has increased by 68kPa and pump efficiency by 5%"

His statement concerning the DU% was **"the single jet type sprinklers on the side-rolls are the only ones that are supplied with the irrigation units and why do manufacturers sell irrigation systems with particular sprinklers that result in poor distribution uniformity?"**

A recent trial to improve distribution uniformity has shown excellent results.

The grower commented that he was **"willing to trial several new blocks of double jet sprinklers along the side-rolls to measure any difference before spending the necessary money to improve the whole system"**. *(120 sprinklers @ $35ea. $4,200)*

Involvement

Early in January 2001 the grower was approached on the recommendation of Mr Phil Burrill, DPI Extension Agronomist, who said that they are regarded highly in the district as being experienced, innovative farmers.

Not long after the site was set-up with the moisture monitoring equipment RWUE staff held a field day, with grower co-operation, at the demonstration site.

This day provided local growers with information about

- The project and its dealings with the demonstration site
- The benefits of measuring soil moisture
- The Financial Incentive Scheme and how it could benefit them
- Improvements in Lucerne varieties
- The benefits of system checking with the opportunity to have their system checked by RWUE staff

The grower is constantly trying to improve farming practices and, with some help in the monitoring of changes, are forging ahead despite water restrictions and the need to purchase water.

On the Lucerne paddock he is having problems with waterlogging due to soil compaction and subsequently Lucerne is dying and grass is becoming a problem. As a field trial he is currently using an aerator unit across one section of the paddock and is monitoring the differences.

He has also recently borrowed a hay conditioner, which decreases the drying time between cutting and bailing. This will improve his irrigation scheduling and reduce the amount of soil moisture lost during this process.

The family are prominent members of the newly formed co-operative, Three Rivers Lucerne, of which there are approximately 25 members.

This group has been invaluable as a finite group with whom to conduct extension activities. All activities that are occurring on the demonstration site property are spoken about at board meetings and are a great benefit for all concerned.

The co-operative grower received a regional award for the Border Rivers Region as part of the RWUE project, Irrigator of the Year Award, which was given at the end of 2001.

RWUE Activities

In January 2001 the project team installed an EnviroSCAN®, a MetosCompact® Weather Station and a Tipping Bucket Rain Gauge, which are all remotely accessed by RWUE staff and the grower.

An EnviroSCAN® is a continual moisture-monitoring unit that utilizes capacitance sensors at varying depths within the soil profile.

Installed were 2 x 1 metre probes with sensors at 100, 200, 300, 600 and 900 mm in depth and 1 deep probe at 2 metre in length with sensors at 100, 300, 400, 1000, 1300, 1600 and 2000 mm.

The standard 1 metre probes were installed to monitor irrigation movement and moisture extraction at certain depths in the soil profile.
The deep moisture probe was installed following their expressed concern that he may have been applying excessive water at each irrigation interval and incurring losses of a valuable resource to deep percolation. This probe is now part of the aeration trial area.

The weather station has enabled us to monitor crop evaporation rates and has become the main source for rainfall measurements.

To irrigate the Lucerne they operate side-roll (bike shift) irrigation systems. There are three units of varying lengths – 300 metres, 600 metres and 450 metres. Supplied with the side roll units are Nelson F33 single jet brass sprinklers with 7/32 brass nozzles.

An irrigation system check was conducted in September 2001 on the three side-rolls and two pumps.

A Southern Cross-centrifugal pump supplies enough water to use a 600 metre side-roll and a 300 metre side-roll simultaneously. At the time of this test the pump was operating at 67.4% efficiency. It was at this stage that the grower found there was a possible problem with the pumping unit. Subsequent searching found that two flange facings, that were misaligned, were causing a restriction. This problem has since been rectified and an improvement in pump pressure has thus improved efficiency of the pump by 10%.

The side-rolls were operating at a sufficient pressure, 43 psi, but distribution was poor at 64% for the 300m unit and 52% for the 600m unit.
These figures are well below an achievable benchmark figure of 75% DU for side-roll and hand-shift irrigation systems.

The third side-roll which is 450 metres in length is supplied with water by a Grundfos centrifugal pump. This system overall is very efficient. Distribution Uniformity was 75.2% and pump efficiency was 80.4%.

In January 2003 project staff trialed the use of 5 Nelson F33, double jet, impact sprinklers on the 300 metre side-roll
This particular side-roll was chosen because of its evenness in pressure along the spray-line.
The previous single nozzle size used was taken into account, 7/32 which discharges at 34 litres per hour.
The new double nozzles, 3/16 in the front and 1/8 in the back, were chosen to give the same output without losing discharge pressure.

A second distribution uniformity test has been conducted to measure any improvement using the double jet sprinklers.
Results for this test are very positive showing an improvement of 26%, up to 90% DU. Average application was down 1 mm per hour but I feel that this has occurred because the old sprinkler nozzles were most likely worn and discharging at a greater rate.

This has been a very worthwhile exercise as there are many side-roll units within the Border Rivers and Callide regions. The majority of these systems were supplied to growers with single jet sprinklers and this simple test has shown that major improvements can still be made to improve their efficiency.

Further trials on side roll units have resulted in sprinklers being used outside their optimum operating conditions. It is now view that by decreasing line pressure for the 300 m side roll, so that the sprinklers were operating between 35 and 40 psi, would increase distribution uniformity. This would then save the expense of purchasing new sprinklers for this particular side roll.

Improvements via RWUE Involvement

Previous seasons, 2001 – 2002, yield per Mega Litre data has been collected and collated from the 20 hectare Lucerne block that the EnviroSCAN® units are situated on.

Their yield for the season was very good at 19.92 tonnes per hectare and using only 0.589 Mega Litres per tonne. This equates to 14,725 litres of water used to produce 1 x 25 kg bale of Lucerne.

These figures compare very favourably to long established benchmarks of 0.73 Mega Litres used to produce 1 tonne of Lucerne.

They have been keeping accurate hay production and irrigation records and it is viewed that a more even growth, higher yields and improved hay quality should result with a higher Distribution Uniformity %.

Hard Hose Traveller / Hand Shift
Laidley District
Ken Bullen, Gatton & Scott Wallace Toowoomba

Summary

- **Soil moisture monitoring equipment gives an accurate indicator for irrigation scheduling**
- **Lower costs per hectare**
- **Higher application rate per hectare**
- **Increase in distribution uniformity has resulted in a more even growth of Lucerne and improvement in quality**

Learning's

"Travelling irrigator was inefficient for the job required"

Although more laborious, changing to a hand shift irrigation system has proven to be beneficial. With reasonable distribution uniformity the traveller was not applying sufficient water and Lucerne growth had a strip affect across the paddock

"The system checking highlighted the inefficiencies of the hard hose irrigator"

"The Lucerne grows more evenly across the paddock and quality has improved"

"Able to irrigate effectively to the headland"

Changing from one system to another meant that only one (1) pumping unit was required instead of three (3).

"Power costs have decreased considerably"
In August 2001 an EnviroSCAN® unit was installed

"Soil moisture monitoring equipment gave us an accurate indicator for irrigation scheduling"

This farming enterprise commenced business, in 1998, within the Lockyer Valley and having initially produced vegetables they are now producing Lucerne hay (30ha) and winter hay crops such as barley.

When the RWUE project began the grower became involved with the QFVG RWUE program and was attending workshops / field days. Through this association and their interest in developing their own Lucerne growing practices further we, RWUE Dairy & Lucerne, were approached. Our staff contacted the grower and the demonstration site was established.

The property has good quality underground water available from four bores, which have a pumping water level of approximately 15m. When the property was purchased they also took ownership of a hard hose travelling gun. Initially to improve the system they networked the four bore pumps but soon realised that the travelling gun was inappropriate in a number of aspects for their requirements.

In August 2001 an EnviroSCAN® soil-moisture monitoring unit was installed on a newly sown area of Lucerne. The unit consists of a continual logger unit, two probes with sensors at 10,30,50,70 and 100cm, GSM telemetry communication capability and a tipping bucket rain gauge. The soil that the probes are situated in is a deep dark alluvial clay loam, with a RAW (readily available water) of approximately 60mm in the top 70cm soil profile.

The software associated with this system was installed onto the family computer and the grower received instruction on its uses and practicalities. The GSM telemetry unit enabled remote access to the information, which allows them to download the data and make critical decisions concerning application rates and scheduling.
Toowoomba based staff are able to download this information allowing them to monitor practices, check for faults within the system and establish more accurate scheduling practices.

In September 2001 a system check was completed on the hard hose travelling gun. The check returned a poor result, which emphasised the feelings that they had about the irrigation unit. The main concerns were that this system wasn’t delivering the crop water use requirement and was costing a substantial amount in terms of $/ML.

The problem of the hard hose traveller not applying the required amount is most evident on the EnviroSCAN® graph during the period of October 2001 til the end of February 2002.

The system check, and the experience of the travelling gun during this time period convinced them to dispose of that particular unit and utilise some of the unused hand - shift sprinkler system that was already on-farm.
Since February 2002 they feel that they are more capable of maintaining crop water usage rates as required. They have more control concerning the application rate now and this has enabled them to improve yield quantities and decrease on-costs.

The soil moisture probes have now been in the ground for two seasons and they are able to interpret the data with minimal interference from RWUE staff. During the winter period, 2002, RWUE staff spent time with the grower determining, to a finer point, what the EnviroSCAN® data was telling us.

The soil moisture data combined with information from them concerning irrigation dates and hours of irrigation we were able to set irrigation scheduling parameters for their particular farm.

The data is now being used by the grower to closely monitor soil moisture levels in the effective root zone (0-70cm) in an established Lucerne paddock considered to be typical of Lucerne blocks on their farm. By operating within the two points (green zone) we are able to determine the correct time to irrigate and the application needed to refill the profile to minimise stress.

During September 2002 another system check was completed on the handshift irrigation unit. The resultant changes have been worthwhile improvements to the efficiency of water use on this farm and a considerable cost savings.

- 74.8% to 80.2% using the hand shift
- 14.9 kW/hour compared to 45 kW/hour resulting in a saving of $14.86/ML
- Improved application rate of 14.8 mm/hr compared to 7.7 mm/hr

The EnviroSCAN® data is indicating that application rates have been greatly improve and are now more than capable of meeting crop water requirements and the system check has shown that pumping costs have been decreased because only one pump is required instead of three.

Yield (tonnes/ML), and probably quality of hay ($/tonne) has been improved noticeably, according to the grower. Production figures (tonne/ha/cut) are now being closely recorded. The grower attributes 80% of the crop improvement to improved DU% and their ability to apply more water more quickly, while still avoiding runoff.

The use of the EnviroSCAN® equipment has reduced the guesswork in terms of "how long to irrigate", now that soil moisture is more easily assessable.

This is considered to be an excellent example of how irrigation efficiency can be improved, using relatively simple system checks, coupled with adoption of modern technology for irrigation scheduling. Actual efficiency change (ML/tonne hay) has not yet been quantified, but crop yields are now being recorded to achieve this measurement.

During the season of 2002 – 2003 the grower has began to show interest in the benefits of centre pivots but found paddock configurations were limiting so has turned his interests toward sub-surface drip irrigation.
These issues for the grower have developed and will continual to for the pursuit of efficiency and greater monetary returns from increased yields and quality.

Centre Pivot, Texas.
Ken Bullen, Gatton & Scott Wallace Toowoomba

Summary

- **Lucerne is more even and water logging has ceased within the first span**
- **With the help of soil moisture data, a strategy of two irrigations to refill the soil moisture profile has developed**
- **They would see the benefits of improved DU% if a new rotator sprinkler package was purchased**

Learning's

Only minor improvements were achieved from adoption of some of the recommended system changes. The family appreciates the benefits in improved distribution uniformity (DU%) if they were to invest in a new rotary nozzle package.

The family members and their hay-baling contractor have all said

"There has been a noticeable improvement in hay yield"

"The Lucerne appears to be more even within the circle of the pivot"

"Water-logging no longer occurs in the first span"

The grower has found from using the soil moisture data for management, that a strategy of two irrigations, each applying 20 -25 mm water over two days will supply sufficient water and prevent losses due to deep percolation. The EnviroSCAN® soil moisture sensors clearly demonstrate the success of this strategy.

The grower said ***"Despite water supply restrictions, this irrigation strategy allows us to 'hold the fort' by keeping soil moisture in the 'green zone' and takes care of the crop's peak moisture demand in this severe summer"***

He also added ***"We can see from the graphs when irrigations should occur as soil moisture approaches the 'onset of stress line"***

Involvement

As part of the RWUE project an irrigation management demonstration site was sought in the Border Rivers Region, Texas.

Mr. Phil Burrill, an Extension Agronomist stationed in Inglewood DPI, advised us that the property owner would be interested in WUE work.

The property is situated in Texas, Qld and is positioned along the Dumaresq River, the border for Qld and NSW. Operated by parents and two sons the property produces Lucerne hay and beef cattle.

They are prominent, practical and innovative farmers in the area. The younger son is on the Three Rivers Lucerne Co-operative Board of Directors, a new marketing entity with 25 members, and his father has decades of farming experience in the district.

Situated on the property are three (3) Zimmatic centre pivots and also an end tow system.

As per the demonstration site only one centre pivot is being monitored. This pivot is approximately 25 years old and has remained unchanged, apart from general maintenance, since new. Utilizing impact sprinklers and an end gun the pivot covers an area of approximately 26 Ha of Lucerne pasture for hay production and cattle grazing as needed.

The remaining irrigation systems provide irrigation for the production of Lucerne hay, improved pasture and grains such as wheat and oats.

Due to the light alluvial soil type, which has an estimated Readily Available Water (RAW) capacity of around 60mm/m, a staggered irrigation practice has been developed to maintain soil moisture and minimize deep percolation.

On the 5th of January 2001, 2 x 1m EnviroSCAN® soil moisture probes and a Tipping Bucket Rain Gauge were installed under the monitored centre pivot.

This pivot irrigates an established L55 Lucerne crop, which was approximately 3 years old. The probes produced immediate results showing accurate crop water use for an established Lucerne stand.
The data was monitored, by one of the sons downloading to his home computer, as well as DPI staff positioned in Toowoomba.
Over the period of time that we have been associated with the property the son has left and his father has now taken over the management of the data for the 2002 – 2003 Lucerne growing season. Project staff now download the system from Toowoomba and fax him the graphs with comments/recommendations for irrigation scheduling. He is keeping accurate hay production records for a quantitive comparison of paddock productivity before and after the system modifications.

On 1 August 2001, Project staff performed a system check on the Centre Pivot irrigator. This indicated that:

- Distribution uniformity (DU%) of 67.8%, with an average application of 15mm / hour
- Pump efficiency was 63%
- Pumping costs were $8.74/ML

Compared to our benchmark figures of 90% DU and Pump Efficiency of 75% this system was below average.

Sprinklers being the older "impact" type, and positioned high on top of the centre pivot, produce a spray, which is very susceptible to wind drift, causing further unevenness in spray distribution.

This check also highlighted a typical problem with centre pivot irrigators in that they tend to apply more water than required within the first span.

Consequently, the Lucerne was becoming waterlogged and dying. Weeds were then taking hold in that zone.
The centre pivot is also fitted with a Nelson Big Gun, which is inefficient due to inadequate flow rate at the end of the line.

Studies recently within the cotton industry have shown removing every sprinkler within the first span is most beneficial. It has been accepted that this is a small area in relation to the whole irrigated area of the pivot.

This concept was put forward to the grower.

He said, ***"I would not like a total dead area at the centre of the paddock and would at least prefer something growing"***

Further discussions about improvement of distribution uniformity and co-operation with the grower concerning this problem resulted in the removal of every second sprinkler in the first span.
It was viewed that by applying at least some water in this zone Lucerne would have the opportunity to grow.

A recommendation was also made to upgrade the sprinkler package to more effective modern rotator units. This change is yet to be undertaken.

Following adoption of recommendations to remove every second sprinkler in the first span, a second system check in September 2002 indicated:

- A slightly improved DU of 72%, with an average application of 19mm.
- Pump efficiency of 68%
- Pumping cost of $8.64/ML

Although there has been no great system improvement, and the system is still well below benchmark figures, comments from the grower and his hay-baling contractor have been very positive considering that there was no money out laid

“There has been a noticeable improvement in hay yield”

“The Lucerne appears to be more even within the circle”

“Water-logging no longer occurs in the first span”

Travelling Boom, Greenmount
Ken Bullen, Gatton & Scott Wallace Toowoomba

Summary

- Poor distribution which has been rectified but there are still problems with the irrigator
- Irrigating an area too large for the amount of irrigation supply
- Higher expectation of manufacturers to provide required equipment

Introduction

Grower operates an Upton Travelling Boom and has commented
"I have always suspected that it was applying more water in the centre and that there is a problem with the speed setting across the paddock"

An initial system check on 23rd July 2001 found Distribution Uniformity of 64% with the original Upton Sprinkler package operating at 193 kPa. All of his suspicions were confirmed.

"The system checks highlighted the need to seek an upgrade of irrigator nozzles. They were expensive but I have no doubt of their benefits in improving hay yield and probably quality. I'm keeping production records to try and quantify these benefits more accurately".

"The system checks drew my attention to the need to expect more from manufacturers. They need a good "talking to", in my case on the variations in speed of travel, nozzle sizes and the correct spreader mechanisms".

As part of the third round of the Financial Incentive Scheme, the grower purchased a new Nelson rotator sprinkler package following the first system check. These were installed, replacing the old units and the end guns were also removed.

"The new rotary nozzles deliver a bigger spray pattern than the old nozzles, and there is a marked reduction in spray drift".
The grower stated, there was an immediate difference to how the water appeared to be discharging from the boom.

A second irrigation system check by project staff on 14th November 2002 showed a14% improvement in Distribution Uniformity, (78%), due to this system upgrade.

Although a very keen co-operator in the Irrigation for Profit project, grower has been making little use of the EnviroSCAN® installation in his Lucerne paddock to schedule irrigation applications. He has been using experience gained over the years since installation of the irrigator.

Grower commented, ***“Despite his capability in downloading EnviroSCAN® data, he finds the system is complicated and "unfriendly". Software and interpretation of data have proven complex”***

Involvement

The grower became a demonstration farmer because of his interest in soil moisture information and the ability to measure more accurately. He initially contacted Ken Bullen, who at that time was a Senior Extension Officer for Lucerne growers, and then was directed to Malcolm Martin, Senior Extension Officer RWUEI Project for Lucerne and Dairy.

At this point in time Malcolm was preparing sites in other regions and decided that there would be a mutual benefit by the grower becoming a demonstration farmer.

The main benefits for the grower was the capability of measuring soil moisture on a continual basis with an EnviroSCAN® soil moisture-monitoring unit and to know and understand the amounts of irrigation being applied.

As the RWUEI project commenced there was a requirement for a site situated close to Toowoomba that was within a developed growers district. Also required was a site, which operated a different irrigation system, compared to the other demonstration sites chosen.

The grower is well known within the district and owns and operates a low pressure travelling boom, one of a few for the area.

The grower’s property was chosen because of these factors:

- Greenmount – Pilton area: will provide a focal point for the project, which can be used to provide other growers in the area with required information.

- Low Pressure Travelling Booms are viewed as being ideal systems for their energy efficiency and higher Distribution Uniformity characteristics.

At this stage 2001-2002 data has been collected, collated and compared to the other sites.

The property comprises irrigated established Lucerne on black clay loam with an estimated Readily Available Water content of 90-100mm/metre. The current area of Lucerne within the demonstration site is 11.7ha.

The Upton Travelling Boom is 65m across and had fixed plate sprinklers with two end guns fitted. The optimum lane spacing between shifts appears to be 54 metres.

The pumping unit is an overly large Western Electric motor rated at 55kW (75hp)@ 980rpm.This is attached by v-belts to a Weir 9202 Helical Rotor pump, operating at 461 kPa, delivering 57,780 litres of water/hour and operating at 90.2% pump efficiency.

The general operating time for a complete shift is 14hours @ 27m/hour and at this level of operation the boom was applying approximately 103.7mm/hour at an average depth of 38mm.

He contract bales the whole of his Lucerne hay production as large square bales.

RWUE Project

In early March 2001, project staff installed an EnviroSCAN® soil moisture-monitoring unit.

EnviroSCAN® is a capacitance sensory system, which is capable of continual moisture monitoring at varying depths within the soil profile.

Three x 1metre probes with sensors at 100, 200, 300, 600 and 900 mm in depth and a Tipping Bucket rain gauge were installed. Project staff has download capability, via digital telemetry, for the EnviroSCAN® and the TBRG.

This enables staff to monitor operations of the system for maintenance purposes and determine soil moisture holding capacities for individual sites.

In the case of this site, the grower is able to download and access data himself via his own computer. With combined information and the setting of irrigation parameters his irrigation scheduling can be determined.

During May – June of 2002 yield per Mega litre data was collected and collated for the growing season (summer) of 2001-2002.
With a boom operating at only 64% efficiency, measured at the initial system check, the grower was still able to produce 1 *ton* of hay for every 500,000 litres of irrigation.
This is well below long respected yielding standards for Lucerne of 1 *ton* / 730,000 litres.

The first system check also confirmed an electrical fault, at the pump site, which was subsequently fixed to restore full power.
The second distribution uniformity test undertaken on the 14th November 2002 showed an improvement of 14%.

It is therefore assumed that to irrigate the same area less pumping time and less water will be required and an increase in yield will result.

The second efficiency test still showed faults concerning the speed of travel and the grower is continually working with Upton Irrigation to improve the speed setting, but at a reasonable cost.

Issues

The EnviroSCAN® graphs have helped to determine moisture-holding capacities for this particular site. The software produces a graphical display of soil moisture at varying depths within the soil profile. The results concerning this site clearly show that the grower has been unable to maintain crop water requirements over the production season and has greatly benefited by the occurrence of what little rain has fallen.

At this point I must add that this property received the most amount of rainfall compared to other demonstration sites (750mm during financial year 2001-2002) and he was at one stage able to bale a crop of reasonable Lucerne without irrigating.

In the previous two and a half years that we have worked closely with him the weather has been adverse and now he is under pumping restrictions.

His feelings in hindsight are that he is irrigating a size of area, which he does not have the water for or the pumping time to cover.

Even though he has found difficulties with the software we have managed to provide him with the appropriate graphical tools, which he is able to interpret and make relevant decisions upon.

His candour about his level of acceptance of the scheduling tools is greatly appreciated by project staff. They are important lessons for both the grower and especially project staff and we should keep them in mind in any future attempts at scheduling irrigation on Lucerne and dairy farms.