Macalister Demonstration Farm
Sub-surface Drip Irrigation for Dairy Pastures Project
2009 Season Update

MDF Information Sheet 1
May 2009

BACKGROUND TO THE PROJECT

Sub-surface drip irrigation (SSDI) has been talked about for over ten years in the Macalister Irrigation District (MID). However, it wasn't until early 2008 when a demonstration project proposal was developed by the Macalister Demonstration Farm (MDF) that the concept grew wings. Application for funds was successful with the project supported by a grant of $190 000 from the Victorian Government Sustainability Fund[1] to establish and manage the demonstration through until December 2010. Other support was provided by the Macalister Demonstration Farm, GippsDairy and the Department of Primary Industries.

The objectives of the project are:

- To improve water use efficiency via a trial of subsurface drip irrigation on dairy pastures.
- To demonstrate this technology to farmers both in the MID and state-wide.

WHAT'S IN IT FOR DAIRY FARMERS?

Sub-surface drip irrigation was chosen because it was innovative and had the potential for higher pasture production, to service odd shaped and undulating paddocks, and to create water savings in producing more dry matter per megalitre. However, because it hasn't been proven to work for intensively grazed pasture and has relatively high installation costs, it is seen as a risky investment.

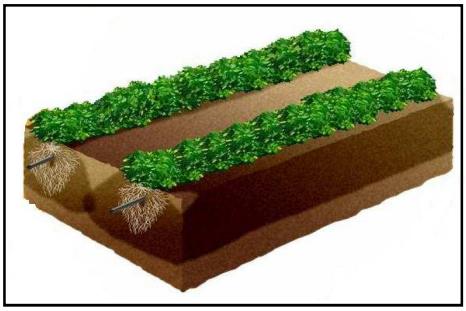
The trial of subsurface drip irrigation at the MDF will enable testing of this technology under commercial conditions while also providing a learning opportunity for dairy farmers in the region. The demonstration component of the project will help to make practical information available to all so that farmers can make more informed decisions for the future.

HOW DOES SUB-SURFACE DRIP IRRIGATION WORK?

Sub-surface drip irrigation delivers water under low pressure through emitters placed below the soil surface right into the root zone. Irrigation management aims to keep the root zone at the perfect moisture level (Fig. 1). Sub-surface drip irrigation has been used successfully in northern Victoria for vegetable and lucerne production.

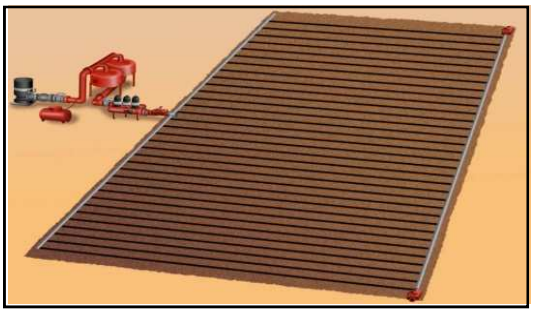
At the MDF water is pumped directly from a Southern Rural Water channel through supply sub-mains to feed the drip line (Fig. 2). The dripline, with emitters at a spacing of 500mm, has been precision laid at a depth of 200mm following deep ripping to allow ease of installation. Whilst it may have been ideal to lay the tapes at 500mm apart to create a regular watering pattern, the cost of the tape and laying it was regarded as too high and an optimum of 800mm spacing between tapes was chosen.

Fig. 1: Graphical representation of dripper line installed subsurface showing soil wetting pattern



Source: Netafim

Fig. 2: System layout with pump and filtration at left supplying water through sub-mains to drip line.



Source: Netafim

HOW HAS THE DEMONSTRATION BEEN SET UP?

The irrigation trial involves the design and installation of 7 ha of subsurface drip irrigation at the MDF. This will be operated under the everyday management system of the farm for three irrigation seasons (part of 2008/09, 2009/10 and 2010/11).

A number of design factors will allow significant comparisons to be made:

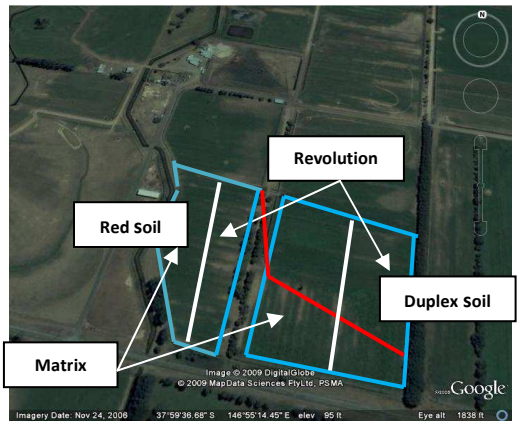
- The site of the sub-surface drip irrigation system has two soil types – a free draining red soil and a duplex soil with the clay base at about 40cm (Fig 3).
- The site of the sub-surface drip irrigation system was sown to two perennial ryegrass cultivars – Matrix and Revolution in late Spring 2008 (Fig 3).

[1] The Victorian Government Sustainability Fund, managed by Sustainability Victoria, supports innovative projects that foster sustainable resource use and have economic and social benefits for Victorians. The Sustainability Fund is administered by the Victorian Treasures and the Minister for Environment and Climate Change and managed on behalf of the Victorian Government by Sustainability Victoria.

- Two other sites on the farm, one under fixed sprays and another under lasered flood irrigation, were nominated for comparison and were sown to the perennial ryegrass Matrix in September and Vatbuster in March 2008 respectively.

Regular monitoring will record details of pasture production, energy use, labour, fertilizer and water use. Moisture loggers have been installed in the paddocks under fixed spray, flood irrigation and in both soil types of the sub-surface drip irrigation paddocks.

Fig 3. Project layout



Paddock preparation commenced in October 2008 so the paddocks were out of production until the first grazing in mid-January 2009. Irrigation commenced in late December after good rains in early December resulted in an excellent seed strike.

The delay in establishing the system and the lack of a water meter at this time to monitor water use has resulted in limited information being available for the 2009 season. The 2009-10 season will be the first full season of the project to allow for a more detailed assessment of performance.

WHAT DID IT COST?

The system was prepared and installed by contractors with little farm labour input. This includes spraying, seedbed preparation and sowing. The result is that the costings reflect the full costs, however considerable cash savings could be made with the input of farm labour, mainly in the connection of the drip lines to the sub-mains. While this is time consuming and a little tedious, it is not highly technical.

Costings have been broken into capital items and installation costs for an irrigated area of 7ha (Fig. 4).

A further section of MDF costs specific to this farm includes the cost of fencing, stock water supply, removal of willows and restoration of laneway. These costs include the input of some farm labour and will vary from farm to farm according to the location of the system and the circumstances of the farmer.

The pumping and filtration systems have been over built to allow for an expansion of the system in the future to an adjacent 7 ha. The extra cost is an MDF specific cost.

Fig. 4: Establishment Costs

CAPITAL COSTS		Total $	$/ha
In the pumpshed		Note: All costs exclusive of GST	
	Pump shed & slab	$ 1,000	$ 143
	Pump and irrigation controller	$ 4,118	$ 588
	Valves and control system	$ 7,545	$1,078
	Filtration system	$ 6,962	$ 995
	Suction line and connections	$ 1,354	$ 193
	Power connection and cabling	$ 6,545	$ 935
	Sub-total (in pumpshed)	**$ 27,524**	**$3,932**
In field	Discharge line, pipes & fittings	$ 9,044	$1,292
	Dripline and fittings	$ 30,007	$4,287
	Sub-total (in field)	**$ 39,051**	**$5,579**
Installation Costs			
	Trenching & installation	$ 17,194	$2,456
	Laying tape	$ 7,360	$1,051
	System commissioning	$ 500	$ 71
	Sub-total (installation)	**$ 25,054**	**$ 3,579**
	TOTAL CAPITAL COSTS	**$ 91,629**	**$ 13,090**
SITE PREPARATION & RENOVATION COSTS			
All farms	Spraying & herbicide	$ 2,091	$ 299
	Cultivation	$ 1,380	$ 197
	Sub-total (Preparation)	**$ 3,471**	**$ 496**
	Seed & sowing	$ 3,205	$ 458
	Sub-total (Restoration)	**$ 3,205**	**$ 458**
	Total Preparation & Renovation Costs	**$ 6,676**	**$ 954**
	TOTAL INSTALLATION COSTS	**$ 98,305**	**$ 14,044**
MDF costs	SRW Private Works Agreement	$ 1,858	$ 265
	Remove fences & troughs	$ 630	$ 90
	Restore fences, troughs, laneway	$ 6,807	$ 972
	System overbuild for expansion	$ 11,890	$ 1,699
	Sub-total (MDF costs)	**$ 21,185**	**$ 3,026**
	TOTAL CAPITAL, SITE PREPARATION, INSTALLATION & RENOVATION COSTS	**$ 119,490**	**$17,070**

HOW DID THE SYSTEM PERFORM IN ITS FIRST SEASON?

Apart from some early teething problems that are discussed later, the hardest element to come to terms with was the absence of water at the surface. Irrigation takes place underground so there is no water to splash through and only a few visible wet patches on the surface – surely the grass can't be getting enough water? However, pasture growth was one of the highlights and could only be described as stunning.

Irrigation on the lasered flood paddock and fixed spray paddock was according to the typical farm schedule, while the sub-surface drip irrigation paddocks were typically watered every third day for six hours in pulses of 3 by 2 hours to better disperse moisture between the tapes, all adjusted for rainfall.

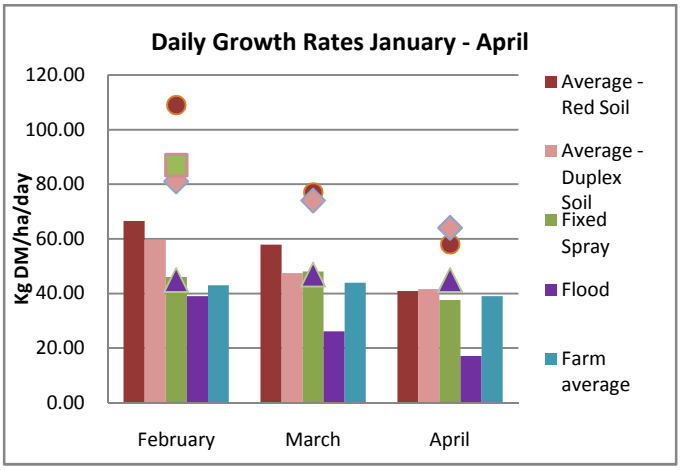
After an excellent seed strike pasture growth proceeded as expected until the first dry period. Pasture growing over the dripline continued to grow strongly whilst those plants between tapes showed signs of water stress and could barely hang on. This resulted in a banding pattern in the pasture (Fig. 5). Pulse irrigating helped and the banding was less obvious following rain and later in the season when the gaps between the rows seemed to close.

Fig. 5 Banding pattern prior to first grazing in January 09

Feed tests were carried out on the pasture to look for any difference in nutritional value. Pasture grown over the drip lines had 16.7% DM, 12.0% ME, 25.3% CP and 42.0% fibre while pasture between drip lines had 17.8% DM, 11.5% ME, 28.2% CP and 44.2% fibre. Good feed by any measure.

Measurements using a plate meter were made immediately before and after grazing on each of the four sites (lasered flood, fixed spray, SSDI – red soil, SSDI – duplex soil) to calculate the average growth rate in the period between grazing. Growth rate is compared in Fig. 6.

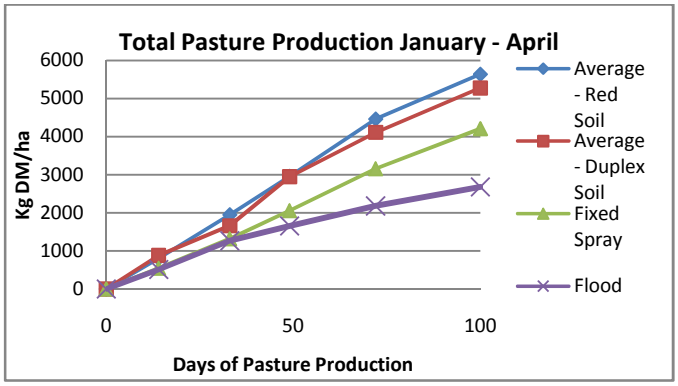
Fig. 6: Comparative growth rates (Growth rate for the best patches in each paddock marked as a point)



Average growth rates were strongest in the paddocks under sub-surface drip irrigation and lowest in the flood irrigated paddock. The greatest difference was in the hottest months – pasture under sub-surface irrigation showed few signs of water stress on even the hottest Jan/Feb days. Growth rate in the best patches of each of the paddocks was also measured with the highest growth rates occuring in February in all paddocks (Fig. 6).

Total DM production over 100 days in Jan-April for sub-surface drip irrigated pasture was 30% higher than for pasture under fixed spray and 104% higher than pasture under flood irrigation (Fig. 7).

Fig. 7: Total Dry Matter production



So why has the pasture performance under sub-surface drip irrigation been so strong? Is it all to do with the new irrigation system? Typically there are four factors that impact on production:

- Pasture species – all paddocks were sown to perennial ryegrass so there is no pasture species difference;

- Grazing management – the MDF manages grazing under Pastures for Profit principles, aiming to graze pastures mostly at the three leaf stage. Strong growth in sub-surface drip irrigation paddocks forced a shortened rotation to be grazed at just over 2.5 leaves. Over January/ February rotation length in sub-surface drip irrigation paddocks was less than 20 days when the rest of the farm was at 30 days.

- Soil fertility – All of the comparison blocks were cultivated and resown as part of the demonstration so all blocks benefited from the release of nutrients following stir up. No fertilizer was added at sowing. Two thirds of the sub-surface drip irrigation paddocks had effluent spread over the surface just before cultivation in spring. Soil tests in April 2009 indicate high levels of nitrate in the soil at a level almost twice that of the fixed spray paddock and 3-4 times higher than the lasered flood paddock. Over the summer period all flood and fixed spray paddocks had Nitrogen and Potassium applied immediately after grazing at a rate equivalent to 1.5 kg elemental N/ha/dy. The sub-surface drip irrigation blocks had only two applications since sowing in November - in February at 1.5 kg elemental N /ha/dy then down to 1 kg elemental N /ha/dy in March after the stock developed sysmptoms of nitrate poisoning. This was further evidence of high nitrogen levels. It seems clear that soil fertility has contributed to pasture growth under sub-surface drip irrigation.

- Soil moisture – Data shows that soil moisture levels in the root zone (20cm) for the sub-surface drip irrigation blocks moved outside acceptable limits (-40 centibars) on just a few occasions and remained there for only 2-3 days at a time. The pattern is the same for readings at 10cm, even though the surface generally appeared to be dry. At this consistent moisture level the plants could not be regarded as stressed – this is consistent with paddock observations. Readings from the fixed spray paddock indicate that up until mid-February moisture levels in the root zone were outside acceptable limits for about half of the time. Readings at 10cm indicated that satisfactory moisture levels were maintained for only 2 days following watering. From mid-February the duration of fixed spray watering was increased but frequency was maintained. This resulted in soil moisture levels in the root zone being maintained at an ideal level for the rest of the season. This was reflected in pasture growth rates that were very similar to those in the sub-surface drip irrigation paddocks in the same time period. Moisture logger data is not available for the flood irrigation paddock.

  What does this mean? Clearly the growth rates for the pasture under sub-surface drip irrigation are stunning. However, it seems that both the high nitrate levels from the effluent as well as very good soil moisture levels in the root zone have contributed to this performance. What is not clear is the impact of the irrigation system alone, although the absence of surface evaporation made it easier to maintain optimum soil moisture levels with the sub-surface drip irrigation system. As nutrient levels drop over the next six months the irrigation impact will become clearer in the next irrigation season. The take home message from the work this year is that if soil moisture levels in the root zone can be maintainedwithin ideal limits, no matter how they are irrigated, then there can be a significant increase in pasture growth rate.

IF ONLY WE KNEW THAT WHEN WE STARTED ...

Like all new systems there have been a few teething problems that point to things that should have been done differently:

- Depth of drip line – laying the drip line at a consistent depth was not easy, especially at the end of each run (and would be even harder in a rough paddock). The ends of some of the drip lines are less than 20cm deep where they connect to the sub-main risers. Whilst we have only cut one so far they really should have been dug in to protect the system in the long term.
- Blow outs – too much time has been spent fixing blow outs in the system. Early on there were a few grommets that blew out of the sub-main but these settled down within a few weeks. The bigger issue was the blow out of joiners that were installed when a new roll was laid into the line. If these were under tension or cross-threaded they invariably blew out. It's surprisingly difficult to find these leaks, especially once the grass is a bit longer. More than once we found leaks more than 40 metres away from a puddle. It would have been better for the rolls of drip line to be in multiples of the length we needed or even sacrificed tape at the end of a run to avoid these in-line joiners.
- Irrigation management - sub-surface drip irrigation is made harder by not being able to see anything! When we first turned the system on we ran it for 48 hours to try and get the moisture to rise up and wet between the tapes. It didn't happen and instead, we created a plug hole for loss to deep drainage. Pulse irrigation worked much better. We really needed some help to understand this different system and how it would behave in our two different soils.
- Uneven paddock - now that the soil in the paddock has settled after cultivation the paddock has become quite corrugated with a depression along the drip line. This will make tractor work like topping pretty uncomfortable. We talked about a light grade after installation but we're not sure that even this would have worked. It might settle a bit more over time.

OTHER OBSERVATIONS

On the positive side, the drip line is surprisingly durable – we had a few lines exposed in a gateway that remained undamaged over four grazings with all of that foot traffic.

We were also surprised by the large number of worms in the sub-surface drip irrigation paddocks. It is unclear whethere this was because of the high level of organic matter in the soil after effluent was spread and the paddock cultivated, or whether the even moisture level without waterlogging was responsible. We'll watch this in the next season.

WHERE TO FROM HERE?

The arrival of the water meter in the next couple of months will enable more complete monitoring next season so we can begin a financial analysis of the performance of those paddocks under sub-surface drip irrigation to calculate the return on investment.

The challenges next season will be to fine tune the irrigation scheduling to optimize water use while producing a large quantity of dry matter. There will also need to be some careful juggling of fertilizer application to match pasture needs, taking into account the already high nitrogen levels.

Regular project updates will appear in the MDF Newsletter. The next scheduled field event for the project will be in May/june 2010.

Technical Specifications

System designed by:	Netafim Australia
System installed by:	McCracken's Water Services
Driplines:	Netafim Python 25250 with 1.05L/hr emitters spaced every 0.5 m.
Control system:	Netafim NMC Junior with electric over hydraulic system for comms to valves.
Mainline:	Class 6 150mm RRJ PVC.
Submains:	Class 6 PVC of 100, 80 and 50mm flushing manifolds with Philmac 50mm ball valves and 25mm vacuum breaker.
Pump:	Grundfos NBG 80x65-160 with 11kW, 3 phase motor. Maximum pump duty 23l/sec at 32m increasing to 25l/sec during filter back-flush.
Filtration:	Netafim Arkal Spin-klin M626T automatic disc filter – 6 x 5mm filters with 120 mesh discs.