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

2010 Season Update

MDF Information Sheet 8
May 2010

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.

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. Sub-surface drip irrigation has been used successfully in northern Victoria for vegetable and lucerne production. 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 test this technology under commercial conditions. The demonstration component of the project will also enable district dairy farmers to see it working and help to make practical information available so that farmers can make more informed decisions for the future.

The irrigation trial involves the design and installation of 7 ha of subsurface drip irrigation on two different soil types at the MDF. The soil types mentioned (Denison soils and Tinamba red soils) are referred to the SKM Soil Permeability maps for the MID. This will be operated under the everyday management system of the farm for three irrigation seasons. Two other sites on the farm, one under fixed sprays and another under lasered flood irrigation, were monitored for comparison and were re-sown to perennial ryegrass just prior to the installation of the SSDI.

An End of Season Update for 2008/09 has been published that includes the system design, establishment costs and performance. This latest update is for 2009/10; a final update is scheduled for the 2010/11 season.

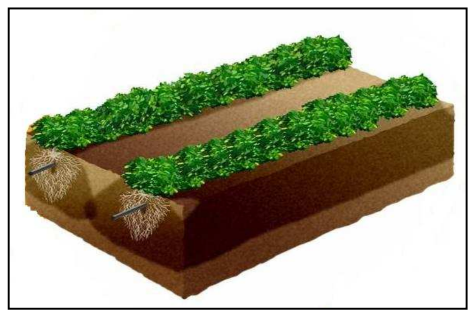
[1] The Victorian Government Sustainability Fund, managed by Sustainability Victoria, supports innovative projects that foster sustainable resource use and have economic and social benefits for Victorians. The Sustainability Fund is administered by the Victorian Treasures and the Minister for Environment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

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).

At the MDF water is pumped directly from a Southern Rural Water channel through supply sub-mains to feed the drip line. The dripline, with emitters at a spacing of 500mm and row spacing of 800mm, has been precision laid at a depth of 200mm following deep ripping to allow ease of installation.

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



Source: Netafim

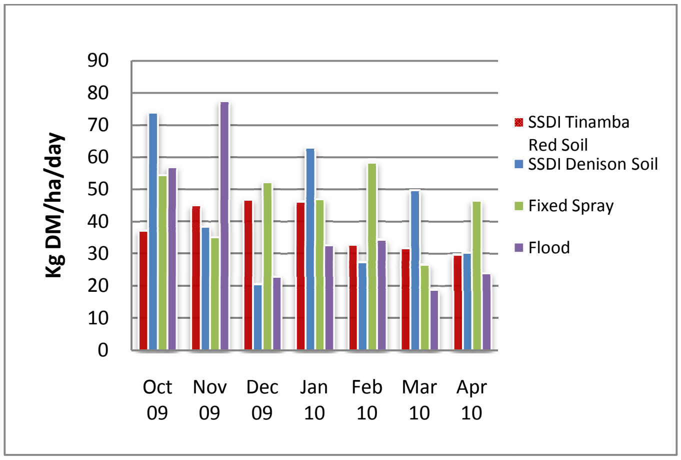
HOW DID THE SYSTEM PERFORM IN ITS SECOND SEASON?

The second season is the first full season of operation with the system becoming operational in December 2008. Performance monitoring has focused on pasture production following a breakdown of the water meter and an inability to measure water usage. It is still the intention to compare the performance of the flood, fixed spray and SSDI systems in ML/ha and ML/tonne DM in the next season.

The 2009-10 season started with a very hot and dry spring followed by a mild and damp summer and autumn. This made it a challenge to keep soil moisture levels at an optimum in spring but delivered times of waterlogging in December and February, both negatively impacting on pasture growth for all three systems.

The highest daily growth rate was achieved on the flood irrigated paddock in November at 77 kgDM/ha/day (Fig. 2), however, from December to the end of the season in April dry matter production did not exceed 35 kgDM/ha/day with the poorest performance in March at 19 kgDM/ha/day. The result for the flood irrigated site was an average of 38 kgDM/ha/day for the season.

Fig. 2: Daily Growth Rates October 2009 – April 2010

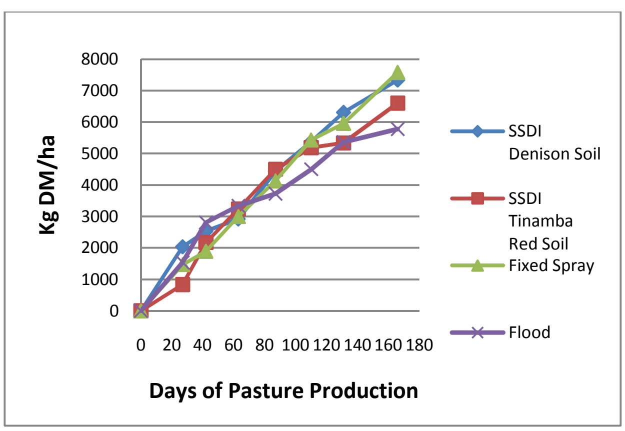


The most consistent growth rates were seen under fixed spray irrigation, with spray overlaps giving even irrigation coverage and limited waterlogging, ranging between 27 kgDM/ha/day and 54 kgDM/ha/day at an average of 46 kgDM/ha/day for the season.

Sub-surface drip irrigation on the Tinamba red soil was also quite consistent, ranging between 30 kgDM/ha/day and 47 kgDM/ha/day but at a lower season average of 39 kgDM/ha/day. However, on the Denison soil pasture response to SSDI was variable, ranging from 74 kgDM/ha/day down to 21 kgDM/ha/day, but at a higher season average of 43 kgDM/ha/day.

Despite the variability in growth rates through the season for each irrigation system, the difference in total dry matter production was not as great as might be expected (Fig. 3). Over the monitoring period of 166 days the highest dry matter production of 7.6 tonnes DM/ha was achieved under fixed spray, closely followed by the sub-surface drip irrigation on the Denison soil at 7.3 tonnes DM/ha. Total dry matter production for sub-surface drip irrigation on the Tinamba red soil was 6.6 tonnes DM/ha and on the flood irrigated paddock it reached 5.8 tonnes DM/ha.

Fig. 3: Total Pasture Production October 2009 – April 2010



It is interesting to consider the potential production if each system performed at its highest measured growth rate for the whole irrigation season. This is presented in Table 1. All systems had a higher maximum growth rate in the 2010 season when compared

Table 1: Projected Pasture Production at Maximum Measured Growth Rate

	Maximum Growth Rate (KgDM/ha/day)	Projected Total Pasture Production (TonnesDM/ha)
Flood irrigation	77	12.8
Fixed spray irrigation	54	9
SSDI – Tinamba Red Soil	47	7.8
SSDI – Denison Soil	74	12.3

to the 2009 season except for the SSDI on the Tinamba red soil. In 2009 the Tinamba red soil had a maximum growth rate of 66 kgDM/ha/day so the calculation above understates the potential of SSDI on the Tinamba red soil by about 2.8 tonnesDM/ha.

So how do we account for the differences between systems and soil types, particularly when the sub-surface drip irrigation system was the best performed last season?

In 2009 the strong pasture growth under SSDI was put down to high nitrogen levels following effluent application in 2008. It was expected that this impact would be largely lost this season. While the evidence at the time of such a positive impact on SSDI pasture growth was quite strong, comparing pasture growth rates over the two seasons shows that there really was little difference (Fig.4 and Fig.5). The poorer performance on the Denison soil in December and February 2009-10 was clearly due to waterlogging.

Fig. 4: Daily Growth Rate Comparison: SSDI on Denison Soil 2008-09 and 2009-10

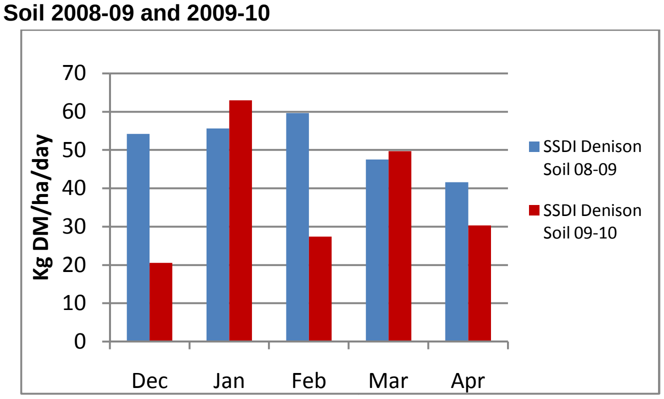
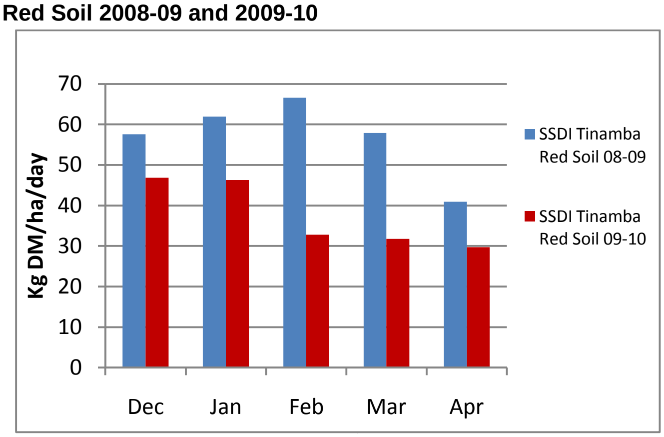


Fig. 5: Daily Growth Rate Comparison: SSDI on Tinamba Red Soil 2008-09 and 2009-10



The difference between the two years in pasture production on the Tinamba red soil can also be explained by the different approach to watering in those two years. The Tinamba red soil has been much harder to manage because it is very hard to get the water to travel sideways between the driplines to create an optimum moisture level across the whole paddock. Last season our response on a number of occasions was to turn the water on for as long as it took to wet the profile and, because of the free draining nature of the soil meant that full water capacity lasted only a day or so, the pasture response was impressive. However, it was not realistic to just leave the tap running, we had to find a more efficient way.Late in the season the irrigation schedule was changed to pulsing - short bursts of irrigation with short rest between - and this is reflected in lower growth rates in April than in the hotter months.

Because the project is attempting to identify water efficiencies the pulsing irrigation schedule has been maintained for the whole of the 2010 season. This has resulted in much less water being applied, less apparent deep drainage loss but lower growth rates. While it has been obvious that the moisture level between the driplines has been too low, the nature of the soil meant that it was impossible to achieve an even moisture profile without saturating the paddock.

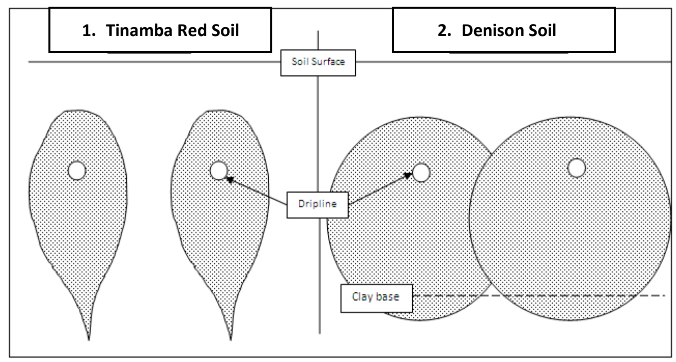
To track soil moisture levels a series of core samples were taken one day after irrigation on both soil types at a range of depths across the distance between the driplines (Fig. 6). In each photo core samples of the same or similar moisture levels are joined by a black line.

You can see that for the tinamba red soil the moisture level at 80 mm below the surface in the column above the dripline (and it was still only moist and not close to capacity) was not achieved in the next column that was only 170mm away from the dripline until a depth of 320 mm. This is considered to be below the root zone for ryegrass. The core samples above 320 mm in that column have virtually no moisture in them.

For the Denison soil there is a dip in moisture level between driplines but there was still adequate moisture 170 mm away from the dripline at a depth of 200 mm (in the root zone) and this dropped to a depth just over 250 mm near the mid point between driplines. In the paddock there was better plant cover between the drip lines on the Denison soil than on the Tinamba red soil.

When the moisture was carefully chased down into the soil it revealed the moisture profiles in Fig. 7. This difference in moisture profile explained why growth between driplines was sparse and stunted, but particularly so on the Tinamba red soil.

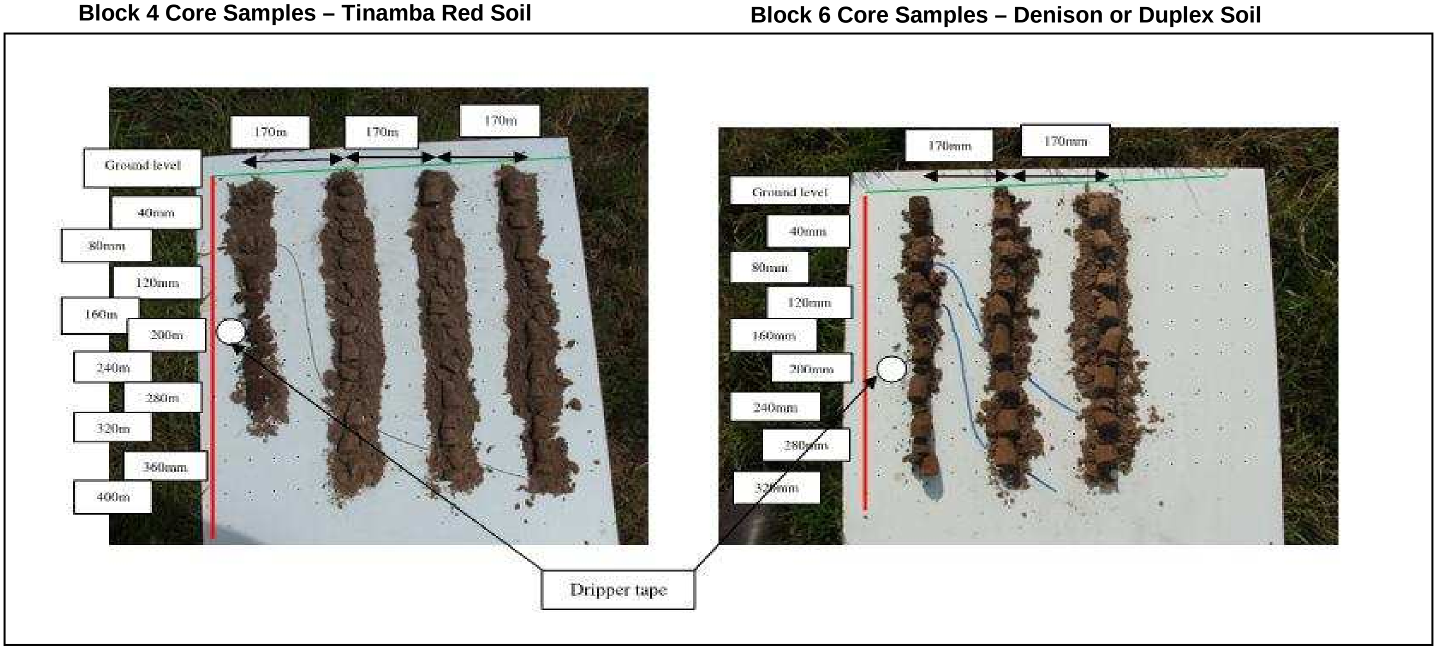
Fig. 7: Soil moisture profile around driplines



It would seem then that a key learning to this stage is that for pasture growth over a SSDI system soil type is very important. To generate the even plant growth across the paddock that will

Fig. 6 Comparison of soil moisture levels in core samples between driplines

Block 4 Core Samples – Tinamba Red Soil **Block 6 Core Samples – Denison or Duplex Soil**



maximise pasture production the soil needs to be of a type that either encourages sideways movement of water or soil that has a clay base at will hold moisture in the root zone, as is the case on the Denison soil. For row crops or crops with extensive root systems, like lucerne, this is less critical as the soil moisture level above the dripline is nearly always at an optimum. However, for shallow rooted pasture plants it can be the difference in making the system worth considering. Another alternative is to move the driplines closer together so less sideways movement is required but this will come at a cost.

The poorer performance of the flood irrigation system is largely the result of rainfall on top of irrigation that extended the time that the paddock was waterlogged and so extended the period of slow pasture growth. Early in the season, when it was hot and dry, pasture production was very high, however in December and late February in a walk through the paddock the signs of waterlogging were clear.

The fixed spray system is installed on the Tinamba red soil so is not as prone to waterlogging. Any rain that fell on top of irrigation moved quickly through the profile and the pasture soon started growing again. This is evident in the consistency of growth rate under fixed sprays.

The pattern of growth over the 2010 season under each of flood irrigation and fixed spray irrigation is very similar to the pattern of growth over the 2009 season.

Challenges to managing a SSDI system

How do we manage what we can't see? Achieving consistent root zone moisture levels is a constant challenge – too much and water goes to deep drainage; too little results in water stressed plants. Monitoring optimum soil moisture for SSDI is very different to surface application – the top 10cm of soil can seem dry while the next 10cm is perfect. Yet monitoring soil moisture level and then irrigating to match soil type is the key to success. We have yet to master this so there is much improvement to come.

Fertilizer application has also created some unexpected issues. We have observed over the past two seasons low level symptoms of nitrate poisoning that has been attributed to high nitrogen levels following effluent application. However we noticed this year that urea spread after grazing on the dry soil surface stayed for days longer than was seen under the other irrigation systems and was not flushed into the soil until there was a shower of rain. The result was a flush of later growth, in some instances too close to grazing. This also meant poor fertilizer utilization that may have reduced pasture growth.

A fertigation unit was installed later in the season to deliver liquid nitrogen fertilizer with the irrigation water to improve utilization and overcome toxicity problems. However, this means that fertilizer is only delivered as far as the water reaches and with the issues we have in spreading the water you can see the effect in Fig. 8. Given that the fertilizer is reaching only a portion of the paddock and losses to the air are minimised the rate of application at 30KgN/ha or 1 kgN/day was half of that applied elsewhere. This variation in growth response is also reflected in overall growth rates.

Fig. 8: Striping after injected nitrogen fertilizer

When you can't see the water being delivered how do you know if each section is being irrigated correctly? A faulty valve solenoid had one section un-watered for more than a week before we picked it up. It impresses the need for checking the system fully in each cycle. This is not time consuming but competes with other jobs on the farm.

Leaks in the system occur occasionally and are very hard to track as water gathers at the lowest point of the paddock. Some areas that were waterlogged last season and have been slow to recover with a change in soil structure resulting in a change in grass species and loss of production.

Is SSDI the answer for dairy pastures?

We've seen:

- strong pasture growth that shows the potential of the system;
- A positive response to hot weather if soil moisture level is right;
- A flexible system that can deliver water where and when it is needed.

We've been challenged by:

- High installation costs;
- Different soil types that have different watering requirements;
- Keeping soil moisture levels even across the paddock and at an optimum to maintain high levels of production.

The jury is still out as to whether SSDI has a future in pasture based dairy production so assessment of the system and its performance needs to continue.

WHERE TO FROM HERE?

Because we were not able to collect some critical data this season the project will continue for another year. This will also enable us to fine tune the irrigation system to remove the ups and downs of pasture growth caused by conditions too dry or too wet.

A block of faulty dripline has also been removed and the manufacturer, Netafim, has generously agreed to replace it at a narrower 500 mm row spacing. This will enable us to measure any difference in performance under a more intense design. The results will be very interesting.

Watch this space.