SMARTER IRRIGATION FOR PROFIT 2

Dardanup Dairy Optimisation Site

TECHNICAL REPORT

SITE BACKGROUND

Dairy Optimisation Site Coordinator: Sam Taylor

Owner: Michael Twomey

Location: 220ha farm at Dardanup, close to the south-west regional centre of Bunbury, Western Dairy Region, Western Australia

Herd size: 330 mixed Holstein/Jersey cows, associated calves and dry stock

Irrigation site and set-up: 100ha with four centre pivots designed to operate concurrently to maximise the use of off-peak power. The optimisation site comprised 5ha of predominantly white clover, with a smaller percentage of chicory, millet and kikuyu during the primary irrigation period and typically biannual ryegrass late autumn through to mid-spring, irrigated by Pivot 3.

Extreme heat is a challenge for farmers of the region, with high evapotranspiration (ETo), which affects yields over summer.

Irrigation season: October–March/April

Site questions

- Will commencing irrigation earlier in the season (mid-spring) to extend the biannual ryegrass avoid a green drought scenario?
- Will an irrigation strategy based on depleting and refilling within the readily available water (RAW) zone throughout the dry season increase dry matter (DM) production in Season Two and Three of the project?
- Is the current irrigation system operating efficiently and according to specification to maximise production uniformly across the site?
- Will increasing the application volume but decreasing frequency to maximise use of off-peak power still maintain soil moisture within the RAW zone?

Key messages

- Soil moisture monitoring technology is highly recommended for irrigators of the Western Dairy region to monitor and maintain soil moisture within the RAW zone.
- Constraints to maximising water productivity at this site were soil sodicity, water quality and pasture suitability, which affected millet establishment over two seasons. The prevailing white clover pasture was severely affected by heat stress at the height of summer. As well as precision scheduling, appropriate species for the soil type and regional climate must be established to capitalise on irrigation investment.
- Applying higher rates of irrigation less frequently maintained soil moisture levels within the RAW zone during Season Three. The growth rate response was an increase of 59% (tDM/ha/day) compared to Season Two and energy costs reduced by 53% ($/tDM). Gross productivity water use index (GPWUI) doubled to 0.89 (tDM/ML), but was still below the industry benchmark of 1–2 tDM/ML.

Australian Government
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Dairy Australia

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Technologies and strategies used

- Three 40cm EnviroPro® capacitance probes with Wildeye® loggers/telemetry installed to represent varying soils and locations under the pivot (1: Outer Ring, 2: Middle Ring, 3: Inner Ring). The Middle Ring probe was used to inform irrigation decisions as an intermediate reference point for soil characteristics and system application.
- Rain-gauge installed with tipping bucket.
- Rainfall data obtained from the nearest Department of Primary Industries and Regional Development network weather station.
- The tools most used and valued by Michael Twomey and reference group members were:
  - soil moisture monitoring using the EnviroPro®/ Wildeye® equipment
  - SWAN Systems Weatherwise forecasts were not relied on; correlation of actual versus forecast ETo over the summer of 2021–22 were highly accurate.
- IrriPasture was used in Seasons Two and Three primarily by the site coordinator:
  - **Pros:** simple to read with good correlation between Season Three Wildeye® soil moisture graph and the IrriPasture water budget graph for the same period.
  - **Cons:** requires too much input and analysis compared to using soil moisture probes.

Findings

The analysis of the yield, energy and water data collected over Seasons Two and Three are detailed in Table 1. Figures 2 and 3 show the summed soil moisture status at the Middle Ring soil probe for Seasons Two and Three.

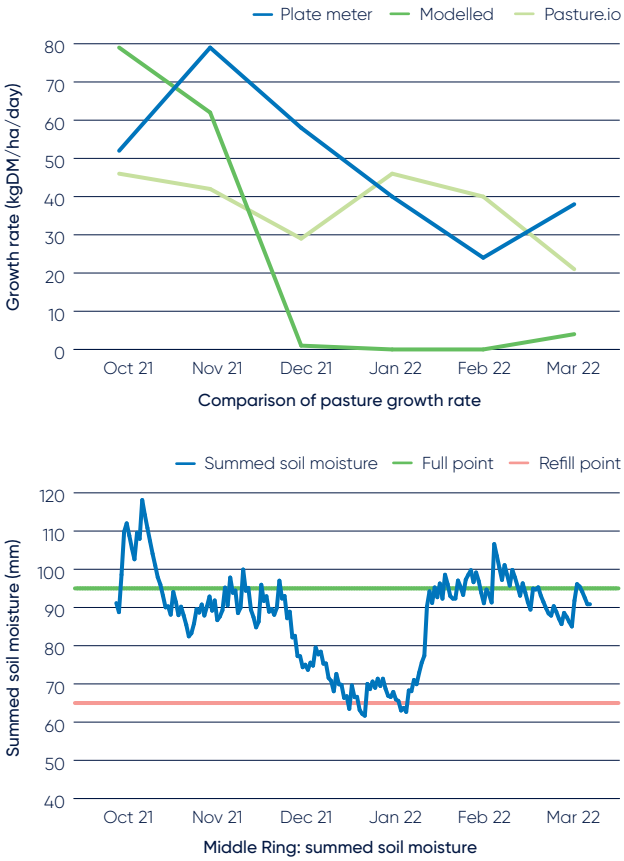
Table 1 Seasonal metrics results

Production*	**Season Two**	**Season Three**
Growth rate (kgDM/ha/day)	28.78	48.56
GPWUI (tDM/ML) rainfall and irrigation	0.44	0.89
Energy per irrigated ML (kWh/ML)	215.55	215.55
Energy per tonne DM (kWh/tDM)	386.72	204.65
Energy used per ML irrigation per m head (kWh/ML/m head)	5.41	5.41
Costs	**Season Two**	**Season Three**
Water costs per tonne DM ($/tDM)	0	0
Energy costs per tonne DM ($/tDM)	$56.07	$29.67
Energy costs per ML water ($/ML)	$31.26	$31.26
Energy costs per ML irrigation per m head ($/ML/m head)	$0.78	$0.78
Total cost per tDM ($/tDM)	$56.07	$29.67
Total cost per hectare ($/ha)	$132.34	$259.35

**Energy use (kWh/ML) was determined across both seasons based on findings of the 2021 Irrigation System Evaluation Report. This was deemed more accurate than previous determinations based on farmer historic information. Includes pumping from storage dam to pivot 3 only. Measurements for Season Two were for 82 days and for Season Three 180 days.*

Figure 1 Season Two

Figure 2 Season Three



- In Seasons Two and Three, oversowing of millet into white clover pasture base in early spring was not successful, so site constraints and other factors that affect yield performance under irrigation, such as site soil characteristics, irrigation water quality and pasture/crop selection, were investigated.
- 'Typical' irrigation in Season One and Season Two (until January) did not maintain soil moisture within the RAW zone. In Season Three, irrigation scheduling changed from frequent and smaller rates of application (5–6mm) to less frequent and higher rates of application (range 12–13mm) by slowing the wheel speed. These applications more closely matched ETo (3–9mm/day) and improved the water penetration. Soil moisture (Fig. 2) was primarily maintained within or above the RAW zone (short periods just below refill in the height of summer) and the effectiveness of irrigations was confirmed with moisture response at 30cm and 40cm depths.
- Irrigation events in Season Three were targeted at weekend off-peak power periods, though some were necessary during the week and subsequently overlapped into peak periods. However, energy costs remained the same as in Season Two, but with improved efficiency ($56.07/tDM Season Two versus $29.67/tDM Season Three – Table 1). As the ETo rates reduced into March of Season Three, application frequency increased, with reduced rates of application, using only off-peak power.
- Although irrigation start-up occurred one month earlier in Season Two than in Season One, DM results were significantly below modelled potential growth rates in spring (Fig. 1) and ultimately declined. The modelled data show the effect of extreme heat on white-clovers during the summer months, despite adequate soil moisture. Measured DM results in January of Season Two (4 kgDM/ha/day) led to the decision to stop irrigation. In January of Season Three, the growth rate had improved (40 kgDM/ha/day) but declined in February (24 kgDM/ha/day). At other pivots across the property where millet establishment was good, pasture growth/production remained at high levels.

Changed irrigation practices improved both average growth rates and input efficiency.

- The largest difference was within the first three months of the irrigation season (October – December) where in Season Three an average growth rate of 63 kgDM/ha/day was achieved compared to 37 kgDM/ha/day in Season Two. The GPWUI achieved in Season Three was below the industry benchmark of 1–2 tDM/ML at 0.89 kgDM/ha/day.

Table 2 White clover growth rates achieved and temperature observations of Season Three

Measurement period	Growth rate kgDM/ha/day	No. of temperature observations	% observations >30°C
18 Oct–12 Nov	62.8	600	0
13 Nov–3 Dec	90.5	481	2
4 Dec–27 Dec	54	555	12
28 Dec–18 Jan	50	500	20
19 Jan–7 Feb	25.6	357	34

- Improved irrigation practices did not result in maximised water productivity to establish millet in summer and annual ryegrass in autumn because of the following constraints:
  - **Site characteristics:** High sodium levels reported in soil tests conducted in Season Two (12% exchangeable sodium percentage (ESP) in 0–10cm and 20% ESP in 10–20cm), affecting both pasture growth and the effectiveness of irrigation/rainfall.
  - **Quality of irrigation water:** High sodium adsorption ratio (measured at 5.2, ideally should be <3), which affects pasture growth and soil stability.
  - **Suitability of pasture type:** pasture/crop should make the most of available water in spring and summer months once average temperatures rise. The pasture sward was dominant in white clover, which has a temperature range for optimal growth of 18–30°C. DM measurements between 18 October and 12 November 2021 revealed a pasture growth rate of 62.8 kg/ha/day when the temperature did not exceed 30°C. From 13 November to 3rd December 2021, pasture growth increased to 90.5 kg/ha/day. During this period only 2% of temperature observations (481) exceeded 30°C. As temperatures increased into summer, pasture growth rates declined (Table 2), with similar observations for the remainder of February. Pasture growth increased marginally to 37.6 kg/ha/day once temperatures cooled during March 1–28. Of 658 temperature observations, only 10% were >30°C.
- Millet is heat tolerant and maintained pasture growth rates under other pivots of the property where it was successfully established. Millet would also shade the white clover, possibly altering the local microclimate and allowing higher growth rates for the white clover than were recorded on the optimisation site. The proposition of extending the growing season of the ryegrass was unable to be tested, due to the lack of established ryegrass in late spring/summer.

Irrigation system evaluation

Table 3 Reported irrigation system evaluation metrics

Evaluation year	Flow rate (%)	System capacity (mm/day)	Co-efficient of uniformity (%)	Distribution uniformity (%)	Application V panel (%)	Pump efficiency (%)	Energy use (kWh/ML/m head)	Average application rate (mm/h)	Centre pressure (%)	End pressure (%)
2021	0	22	89	85	+40	55	5.4	66	+161	+299

Distribution of water along the length of the pivot was above industry benchmarks (Table 3), but improvements were recommended to reduce energy costs.

- Pump efficiency was measured as 55%. In the design and commissioning of the system, some pump efficiency was sacrificed by selecting three identical pumps to ensure back-up should a pump fail. Although the pump is performing as expected, it is low efficiency, resulting in higher than necessary energy costs.
- Improving pump efficiency to 75% would result in cost saving per ML (@ 30 cents/kWh) for operating Pivot 3 of $19.89/ML. Therefore, based on the applied water of 41.49ML in Season Three, the seasonal energy cost saving would be $825.24 for Pivot 3 alone.
- A more suitable pump and/or making more use of the variable speed drive (VSD) would address over pressurisation issues (Table 2), a legacy of Pivot 3 once operating an end-gun. Caution needs to be taken to ensure adjustments of the VSD do not nullify gains made by improving pump efficiency.
- Actual application rate and the control panel setting showed a large difference, resulting in 40% over-watering at each irrigation event. The recommendation was to recalibrate the control panel, but in Season Three manual recalibration was performed at each application.

Reference group support

- In late 2019, a small group of regional farmers met on site to provide input into the site questions but, given the geographic distance between dairy farms of the region, ongoing extension was through annual pasture walks and dovetailing of SIP2 updates into Western Dairy major events (Annual Spring Field Day and Annual Dairy Innovation Day) for 295 attendees.
- In Season Three, a total of 24 *Weekly Irrigation Requirement Reports* were prepared and emailed to Michael Twomey and the original group of nine involved in start-up activities. These presented commentary on the effectiveness of irrigation events on soil moisture over the past seven days, in the context of rainfall and ETo, including presentation of the Middle Ring soil moisture graph. A table was also prepared each week to demonstrate the comparison in soil moisture levels between the three installed probes, using numerically presented stress and field capacity points, and actual readings across the season. DM commentary was also included each time a measurement was done. The reports concluded with recommendations for the week forward. Michael Twomey and the support group found these reports extremely useful and responded accordingly to the advice provided each week.
- The site featured in two national publications: *Farm Online* and *Australian Irrigation Magazine*, as well as having three articles published in the Western Dairy Newsletter. The national coverage helped to bolster dissemination of the site's activities to over 15,000 readers.

MORE INFORMATION

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