SMARTER IRRIGATION FOR PROFIT 2

Mt Gambier Dairy Optimisation Site

TECHNICAL REPORT

SITE BACKGROUND

Dairy Optimisation Site Coordinator: Cathy Ashby

Owner: James Mann

Location: Donovan's Dairy, close to the border of South Australia and Victoria, DairySA Region, South Australia – approximately two kilometres from the coast, 1,700ha with an 800ha milking platform, 465ha irrigated by nine centre pivots

Herd size: 1800 cows

Irrigation site and set-up: Paddock 6A (13 ha), located under a 15-year-old, 10-span centre pivot (Pivot 6) servicing 81 ha of perennial ryegrass and white clover

Irrigation season: September–March/April

The soils at this site vary significantly with depth ranging from 8–20cm under the pivot and the RAW varying respectively. Soils are a sandy clay loam overlying fine limestone. The challenge of this site, and for most on the Limestone Coast of SA, is management of irrigation on shallow, free-draining soils with evapotranspiration (ETo) rates of 10–12mm.

Site questions

- Will water use efficiency and yield be improved by using technology to understand readily available water (RAW) refill and field capacity limits to accurately schedule the timing and rate of irrigation?
- What is the cost and value of irrigated pasture to the farm business (water, yield, labour and energy costs) and what is the economic effect of changes to irrigation practices and system, including the payback period?

Key messages

- Soils of the Limestone Coast of south-east SA require irrigation applications to maintain soil moisture within RAW. System capacity to increase frequency and rate is integral to optimal management.
- Water extraction restrictions require farmers to determine the true managed capacity of their irrigation systems and adjust irrigation rates to maintain RAW within the allowable application hours.
- Bore water rapidly reduces the effectiveness of sprinklers, affecting water distribution uniformity and pressure. More effective irrigation through improved maintenance identified by system evaluations and subsequent increased yield potential can offset the costs of such evaluations.
- Agronomy and irrigation consultants can work with dairy irrigators to assist with decisions planned or made on soil–plant–water interactions, and therefore production and profitability outcomes.
- Soil moisture monitoring, forecast information and water balance calculations are the key to improving irrigation scheduling to optimise growth rates over summer.

Australian Government
Department of Agriculture, Fisheries and Forestry

Dairy Australia

This project was supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit program.

Technologies and strategies used

- Three 30cm Terros-10® probes with Wildeye® loggers/telemetry installed to represent variations in soil characteristics under irrigation (Normal probe, and a Wet probe) and one dryland location for comparison analysis.
- Local MacDonnell NRM weather station, located near the farm, provided previous seven-day rainfall and ETo data.
- SWAN Systems Weatherwise used for upcoming 7-day rainfall and ETo forecasts.
- IrriPasture was established for the conditions of the 'Normal' probe (RAW = 12mm) and rainfall and irrigation events were input accordingly. The water budget graphs of IrriPasture and the summed moisture graphs of the 'Normal' probe were monitored and compared.
  - **Pros:** IrriPasture aligned with general trends of the 'Normal' probe and ideal for tracking plant water requirements against irrigation plus rainfall. Local weather station data was automatically input. Platform worked well for 2020–21 (Season Two).
  - **Cons:** Manual entry of irrigations, especially when AgSense® already installed to capture irrigation events. Frequent loss of connection with the local weather station in 2021–22 Season Three (issues at weather station end) resulted in inaccurate water balance calculations, often over-specifying the water requirements.
- In Season Two (2020–21), the strategy was to irrigate to supplement rainfall, resulting in applications varying from 4.9mm every 3–4 days from 1 September to applications of 7–10.4 mm in the height of summer primarily 24 hours a day, then scaling back in early autumn.
- In Season Three (2021–22), restricted pumping to between 9pm and 5pm (20 hours/day) limited the managed system capacity to 8.3mm/day. The general approach was 5mm application every two to three days, increasing the frequency in January and February.

Findings

Table 1 shows the dry matter (DM) production, water and power metrics for three seasons at Mt Gambier. Figures 1 and 2 (top) show the measured and modelled growth rates, and the growth rate as measured by Pasture.io. Figures 1 and 2 (bottom) show the soil moisture profiles in relation to the field capacity and refill points for the same time period as the pasture measurements.

Table 1 Seasonal metrics results

Production	Season One	Season Two	Season Three
Growth rate (kgDM/ha/day)	46.29	47.29	51.22
GPWUI (tDM/ML) rainfall and irrigation	1.15	0.84	1.23
Energy per irrigated ML (kWh/ML)	322.75	365.21	299.62
Energy per tonne DM (kWh/tDM)	192.56	296.57	199.44
Energy used per ML irrigation per m head (kWh/ML/m head)	7.34	8.30	6.81
Costs	**Season One**	**Season Two**	**Season Three**
Water costs per tonne DM ($/tDM)	$1.97	$1.52	$1.87
Energy costs per tonne DM ($/tDM)	$43.81	$56.49	$33.99
Energy costs per ML water ($/ML)	$73.43	$69.56	$51.07
Energy costs per ML irrigation per m head ($/ML/m head)	$1.67	$1.58	$1.16
Total cost per tDM ($/tDM)	$45.77	$58.01	$35.86
Total cost per hectare ($/ha)	$483.06	$395.07	$398.55

Figure 1 Season Two

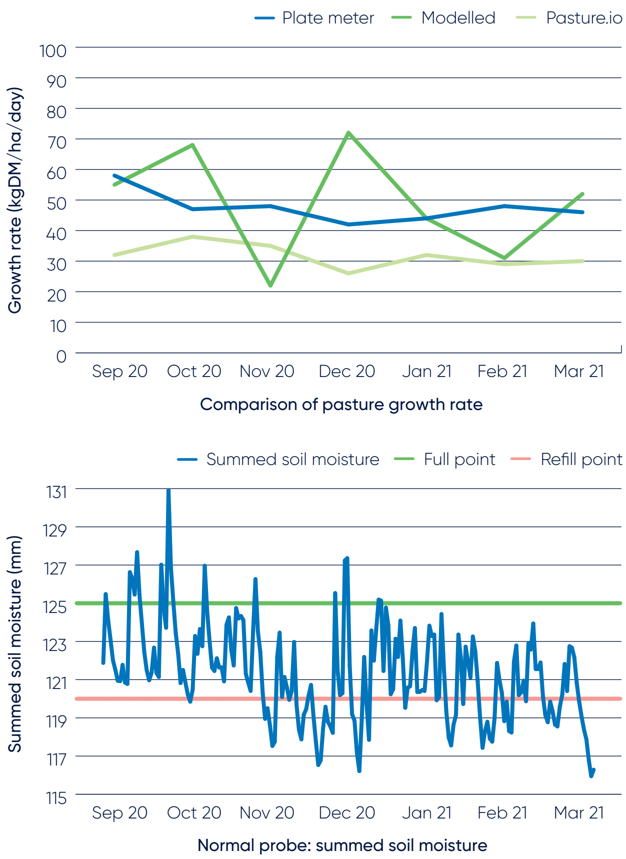
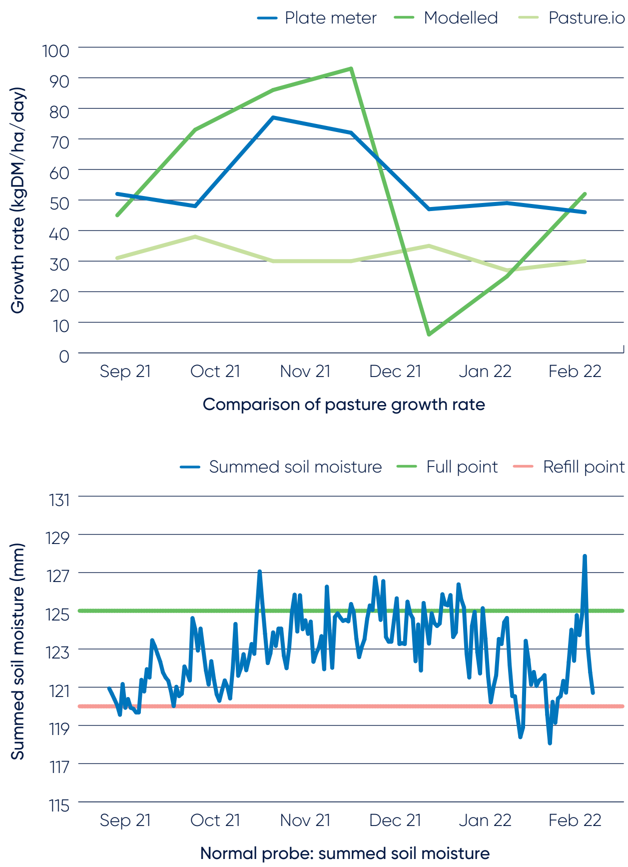


Figure 2 Season Three



- Water costs were less significant than energy costs in irrigation management at this site (Table 1).
- Season Three energy costs demonstrate that the new strategy of applying irrigation over a 20-hour period (9pm to 5pm) plus improved energy efficiency reduced energy costs.
- Average growth rate was similar across the three seasons. Although the gross production water use index (GPWUI) improved overall, and cumulative ETo was not significantly different, Season Two had a number of prolonged extreme heat events and Season Three was milder in temperature but drier for longer over the season. Approximately 17% more irrigation was applied in Season Two (approximately 15% less irrigation plus rainfall in total) than in Seasons One and Three, but resulted in a lower GPWUI due to the heat events.
- Although different irrigation strategies were used in Seasons Two and Three, the RAW of 12 mm was well managed (Figures 1, and 2), likely leading to minimal water loss through the limestone layer. In Season Two a decrease in production was observed between September and October but optimal irrigation management increased the growth in early Summer. In Season Three there were two system failures (flat tyre and a gearbox breakdown) that led to soil moisture declining in January below optimal.
- Timing start-up earlier in Seasons Two and Three resulted in soil moisture being within the RAW zone at irrigation commencement, unlike in Season One. Some 'catch-up' was required after rainfall through November–December in Season Two when irrigation was not commenced on time after rainfall events, leading to a small decline in pasture growth rates (Fig. 1). These events were managed well in Season Three and the trends between soil moisture and pasture growth rate aligned better (Fig.2).
- The modelled average growth rates for both Seasons Two and Three were within ±5% of the actual measured, although the modelled had peaks and troughs in Season Two whereas the growth rate was relatively flat (Figure 1). The modelled data showed a substantial decline in growth rate in November 2020, because of an unseasonal hot spell, but the actual growth rate increased slightly. In Season Three, the modelled data demonstrated a significant drop in January (6 kgDM/ha/day), but the measured growth rate showed only a small decline to 47 kgDM/ha/day.
- Pasture.io aligned with the general measured DM trend over Season Two, but measured 35% below. In Season Three, Pasture.io demonstrated an average growth rate very similar to that of Season Two, but was 55% below the average measured DM, particularly in November and December.
- Pumping for 20 hours/day resulted in a managed system capacity of 8.3mm, which meets peak ryegrass pasture demand.

Irrigation system evaluation

Table 2 Reported irrigation system evaluation metrics

Evaluation year	System capacity (mm/day)	Flow rate (%)	Co-efficient of uniformity (%)	Distribution uniformity (%)	Application V panel (%)	Pump efficiency (%)	Energy use (kWh/ML/m head)	Average application rate (mm/h)	Centre pressure (%)
2020 (limited)	11	N/A	73	83	-15	63	N/A	N/A	+15
2022	8.3*	-13	90	93	-18	57	5.2	71	-8

**Managed system capacity due to 20-hour extraction restrictions*

- Application uniformity appeared to be ideal, but the catch-can evaluation showed a steady decline of the amount applied towards the outer end of the field. The outer three spans and the overhang, which cover 56% of the area, were well below the average application depth of 5.0mm. The recommendation is to install an updated sprinkler package.
- On the flats comprising the majority of the paddock, the pressure at the overhang was excessive, increasing energy use and running costs. The recommendation is to install a variable frequency drive controlled by the pressure at the outer end of the pivot.
- The application rate was 18% lower than the setting of the control panel, resulting in underwatering, and needed recalibration.
- The calculated efficiencies for the three pump duties were 57%, 53% and 45% respectively, all of which were well below the theoretical efficiency of 79–80%. A major recommendation was to replace the pump. Assuming the duty is 108 L/second @ 44.5m head and the pump efficiency improved to 80%, the cost saving per ML (@ 30 cents/kWh) would be $20.14 per ML. Based on the 72ML applied by Pivot 6 in Season Three, the energy cost saving would be $1,450.
- The centre pivot is variable rate irrigation (VRI) capable and fitted with an AgSense® remote control system, although the VRI was not used during the SIP2 project. The VRI prescription prepared for the site in 2017 demonstrated 6.1–9.46mm/ha application rates using segmentation (change in wheel speed) over a number of scenarios requiring 820–892 minutes of system operation. In light of the 2022 system evaluation findings and recommendation, together with the restricted water extraction rules, VRI should be explored.

Reference group support

- There was not a continuous reference group supporting activities. An existing dairy discussion group formed the site questions and attended an annual field day and annual workshop/discussion day.
- A total of 76 *Weekly Irrigation Requirement Reports* were prepared over Seasons One to Three by the site coordinator and emailed directly to 24 local farmers and service providers in the reference group. The reports included:
  - SWAN Systems Weatherwise forecasts for ETo/rainfall at the optimisation site
  - ETo and rainfall data for previous seven-days recorded at the local weather station
  - The Normal and Wet Wildeye® probe stacked and summed graphs
  - Mt Shank and Allendale site probe summed graphs for comparison with other soil conditions of the region
  - IrriPasture water balance graph
  - Pasture.io satellite map of current growth rate predictions of the optimisation site and feed wedge graph
  - commentary on the information and relevance for irrigation requirements and management
  - short item on relevant weather- or irrigation-related issue (e.g. seasonal climate outlooks)
  - promotion of events.
- Having irrigation technicians and the consulting agronomist for the site involved led to robust conversations about the challenges and opportunities to improve irrigation practices.

MORE INFORMATION

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3513.9 | Jan 2023