SMARTER IRRIGATION FOR PROFIT 2

Yarram Dairy Optimisation Site

TECHNICAL REPORT

SITE BACKGROUND

Dairy Optimisation Site Coordinators: Billy Marshall and Robyn McLean

Owner: Shelley Field

Location: Yarram, South Gippsland GippsDairy Region, Victoria, Australia

Herd size: 450 Holstein cows

Irrigation site and set-up: Paddock 2 (3.45ha) and Paddock 6 (4ha), irrigated by a 23ha, 5-span centre pivot

Water supply: groundwater pumped to a storage dam, small percentage from the Tarra River gravity fed into the same dam

Irrigation season: September to April

The 280ha farm has a milking platform of 175ha, entirely irrigated using spray systems: centre pivots, fixed sprays and bike-shift.

There were changes in pasture during the project:

Season One: Paddock 2 – ryegrass, Paddock 6 – ryegrass

Season Two: Paddock 2 – grazed Shirohie millet, Paddock 6 – ryegrass

Season Three: Paddock 2 – new ryegrass, Paddock 6 – ryegrass

Covid restrictions in Season One prevented Victorian Government department personnel from visiting farms for most of 2020, which affected data collection on site. The measurement period was October–February for Seasons Two and Three.

Site questions

- Will irrigation scheduling be improved by using soil moisture monitoring and will this translate into increased dry matter (DM) production?
- Will a summer crop such as millet provide increased Water Use Efficiency (WUE) and comparable DM production to perennial ryegrass?
- What is the DM production difference between establishing (Paddock 2) and established (Paddock 6) perennial ryegrass pasture?

Key messages

- Soil moisture monitoring and forecast data to inform irrigation decisions, especially start-up at the beginning of the season and after rainfall events, improved the yield for perennial ryegrass compared with usual practice.
- Millet is an option for a summer feed crop under irrigation and had good water use efficiency at the site compared to an ageing perennial ryegrass paddock, but site-specific input costs and the non-productive periods during establishment and after spray-out need to be considered.

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.

- Improved knowledge and understanding gained through the Smarter Irrigation for Profit Phase Two Project (SIP2) are transferable across the various irrigated areas of the farm and across other irrigated dairy pastures and crops of the Yarram region.

Technologies and strategies used

- Two 40cm EnviroPro® capacitance probes with Wildeye® loggers/telemetry installed to represent variation in soil characteristics and Paddock location (1: Paddock 2; 2: Paddock 6).
- A rain-gauge installed in Paddock 2.
- A third 80cm EnviroPro® capacitance probe with Wildeye® loggers/telemetry installed in a lucerne crop in nearby Won Wron in Seasons Two and Three, primarily for comparative discussion at extension activities.
- The tools most used and valued by Shelley Field were:
  - Soil moisture monitoring using the EnviroPro®/Wildeye® equipment.
  - AgVic *Weekly Irrigation Requirement Reports*, which included 7-day historic and forecasted. evapotranspiration (ETo) and rainfall data, with irrigation scheduling advice based on a basic water balance. Reports included Yarram and Cobains Wildeye® graphs.

Shelley regularly monitored the soil moisture data to start-up irrigation earlier after rainfall than past practice and maintain adequate soil moisture (readily available water (RAW)) throughout Seasons Two and Three.

- IrriPasture was used across Seasons Two and Three, primarily by the site coordinators:
  - **Pros:** simple to use under most conditions and beneficial for identifying when irrigation applications were below estimated pasture water use, using the ETc graph.
  - **Cons:** reports irrigation is needed when soil is at or near field capacity, according to a calculated water budget. When comparing the Wildeye® summed graphs with IrriPasture's available soil moisture graph (same period after significant rainfall), IrriPasture starts calculating the drawdown of soil moisture on the next calendar day after rainfall, whereas in reality the soil remains saturated for longer than this, slowing plant drawdown.
- The pivot is fitted with variable rate irrigation (VRI) that is not being used. VRI has the potential to irrigate with high water use efficiency, particularly for mixed crop types produced under the same pivot, such as in Season Two, or for pastures of varying age and yield potential, such as in Season Three.

Findings

Table 1 shows the DM production, water and power metrics for two seasons across two Paddocks at Yarram. Figure 1a shows the measured and modelled yields for millet in Season Two and Figure 2a shows the measured and modelled growth rates, and the growth rate as measured by Pasture.io. for Season Three. Figures 1b and 2b show the soil moisture profile in relation to the field capacity and the refill points for the same time period as the millet and pasture measurements. Figures 3 and 4 provide the same data for Paddock 6 for the two seasons.

Table 1 Seasonal metrics results

Production*	**Season Two Paddock 2 (millet)**	**Season Two Paddock 6**	**Season Three Paddock 2**	**Season Three Paddock 6**
Growth rate (kgDM/ha/day)	89.07 (4tDM/ha)	41.10	44.50	42.64
GPWUI (tDM/ML) rainfall and irrigation	2.23	0.96	1.33	1.26
Energy per irrigated ML (kWh/ML)	155.00	155.00	155.00	155.00
Energy per tonne DM (kWh/tDM)	21.09	68.68	55.41	58.21
Energy used per ML irrigation per m head (kWh/ML/m head)	3.3	3.3	3.3	3.3
Costs	**Season Two Paddock 2**	**Season Two Paddock 6**	**Season Three Paddock 2**	**Season Three Paddock 2**
Water costs per tonne DM ($/tDM)	$0.81	$2.62	$2.40	$2.52
Energy costs per tonne DM ($/tDM)	$4.91	$16.00	$12.91	$13.56
Energy costs per ML water ($/ML)	$36.12	$36.12	$36.12	$36.12
Energy costs per ML irrigation per m head ($/ML/m head)	$0.77	0.77	$0.77	0.77
Total cost per tDM ($/tDM)	$5.72	$18.62	$15.31	$16.08
Total cost per hectare ($/ha)	$27.51	$123.98	$100.82	$104.92

*Energy use (kWh/ML) was determined across both seasons based on findings of the 2022 Irrigation System Evaluation Report, which was deemed more accurate than previous calculations based on farmer historic information. Includes pumping from storage dam to pivot only (pump 4).

Figure 1 Season Two: Paddock 2

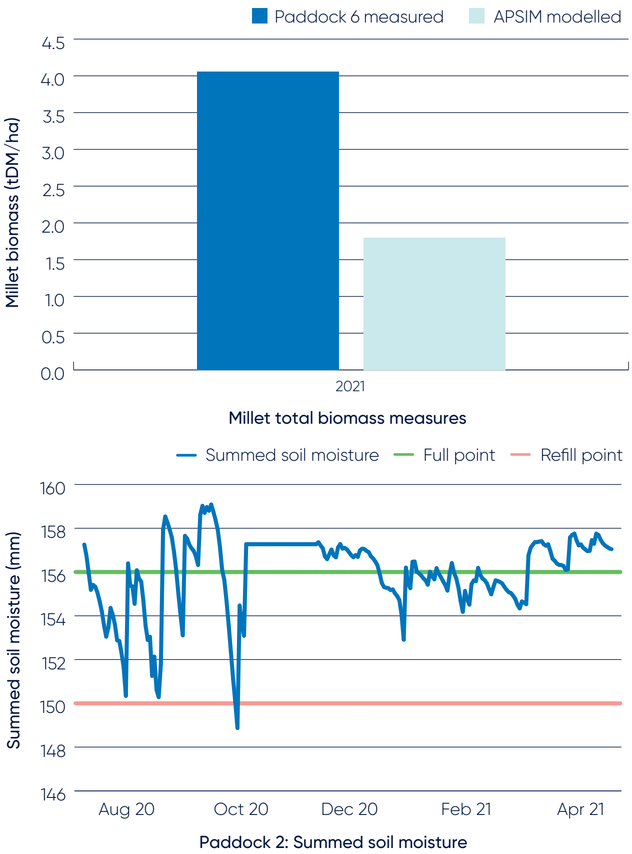


Figure 2 Season Three: Paddock 2

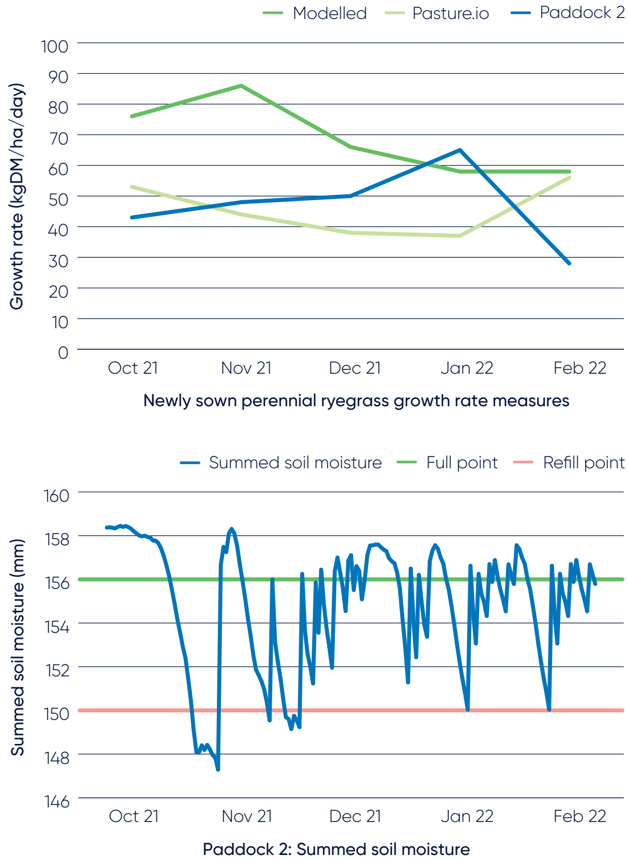


Figure 3 Season Two: Paddock 6

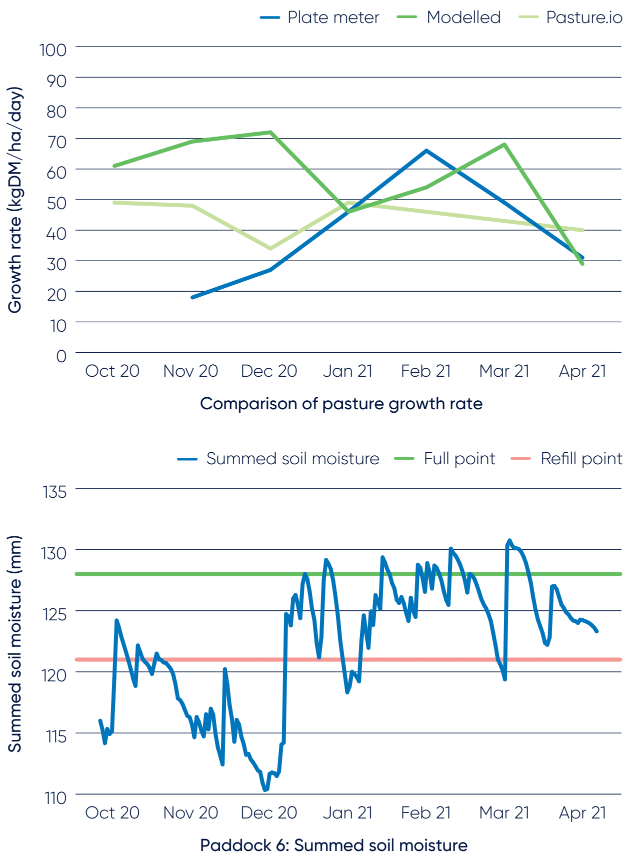
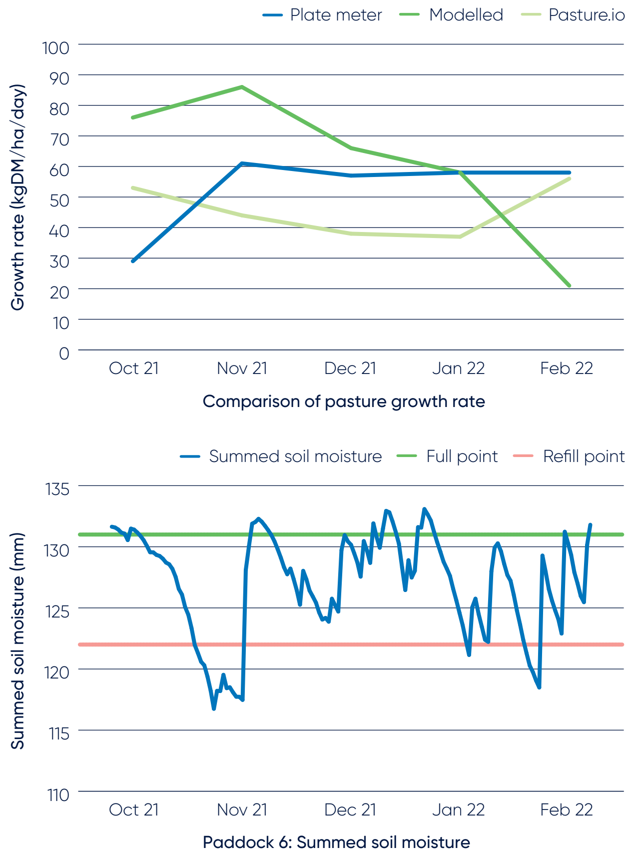


Figure 4 Season Three: Paddock 6



* Modelled yield for millet determined using the Agricultural Production Systems sIMulator (APSIM v7.10) under different irrigation strategies for a range of sowing dates at Yarram using 41 years (1981–2021) of climate data. (Dr James Hill, Dr Matthew Tom Harrison, Dr Ke Liu, Tasmanian Institute of Agriculture). Modelled data has limitations because the dataset is not representative of modern cultivar potential, such as Shirohie.

Season Two

- Performance of millet versus perennial ryegrass under irrigation over summer was investigated. The grazed millet crop was sown in late November 2020 and last grazed on 25 February (54 days). It was compared to the adjacent ryegrass Paddock 6, measured between late October and mid-April (the period between termination of the 2020 winter pasture and first grazing of the 2021 winter pasture of Paddock 2). The yields were 45 kgDM/ha/day and 7.73 tDM/ha for the perennial ryegrass (1.77 tDM/ha less than modelled) and 89 kg/ha/day (over the grazing period) and 4.06 tDM/ha for the millet (over double the modelled). Perennial ryegrass was the better performer in Season Two, taking account of the pasture termination, fallow and establishment periods of the millet in Paddock 2. However, the cool, wet summer of Season Two was more ideal for ryegrass relative to the typical hot, dryer summers of recent years that are better suited to millet.
- GPWUI for the perennial ryegrass and millet was 1.12 tDM/ML and 2.23 tDM/ML respectively. The millet was irrigated less frequently and at lower rates (4.1–8.2mm) than the ryegrass (8.2-16.4mm) based on general advice that the crop is water efficient. The soil moisture data were used to guide these decisions as the season progressed. Improved ryegrass production in Paddock 6 could have been made through improved irrigation start-up at the beginning of the season and after rainfall events. Figure 3 highlights three periods (December, early January and early March) when irrigation was delayed after rainfall, resulting in soil moisture declining below the refill point, which particularly affected measured growth rates compared to modelled in November and December.
- Despite economic advantages in growing a short summer crop versus an ongoing perennial ryegrass under irrigation (i.e. power costs for millet $4.91/tDM vs $13.78/tDM for ryegrass), the energy to the milking herd and overall costs of the millet need to be considered (i.e. cost of spraying, cultivating, seed, sowing, fertiliser and non-grazed periods):
  - Millet has lower energy levels than perennial ryegrass. The metabolisable energy for millet is generally between 9 and 10 MJ/kgDM compared to 11-12 MJ/kgDM for perennial ryegrass during spring and 9-10 MJ/kgDM over summer. In terms of milk production, perennial ryegrass is quality feed throughout spring and moderate-quality feed over summer, whereas millet provides moderate-quality feed.
  - There were six weeks from sowing to first grazing in spring 2020 and a further eight weeks from millet spray-out to first grazing of newly sown perennial ryegrass in autumn 2021 when Paddock 2 was unproductive (approx. 98 days in total). However, the perennial ryegrass of Paddock 6 provided quality feed to the milking herd.

- Agronomists generally advise that millet has an increased WUE and comparable DM production to perennial ryegrass over the summer months. The advantages of millet grown in summer are filling the summer feed gap when perennial ryegrass growth slows and its water efficiency. The disadvantages are poorer feed quality compared to perennial ryegrass and the lag period to establishment before first grazing.

Season Three

- In Season Three, irrigation scheduling improved with the use of soil moisture monitoring. In late October watering was delayed because of forecasted rainfall, which resulted in saturated conditions in both paddocks, and started on time in early December when soil moisture was rapidly depleting (Figs 2 and 4). The summed soil moisture graph of Paddock 2 (Fig. 2) shows that both rainfall and irrigation events maintained soil moisture within the RAW zone and there was only one incident of soil moisture below refill in Paddock 6 in late January. Stacked soil moisture graphs for both paddocks (data not shown) demonstrated water infiltrating down to 30 cm following irrigation or rainfall and the roots drawing moisture consistently at 30cm.
- Paddock 6 was an indicator of improved performance, with similar DM production between Seasons Two and Three, even though no nitrogen was applied in Season Three due to rising costs. The growth rates in Seasons Two and Three were measured at 41 and 42kgDM/ha/day respectively. In Season Three an energy and water cost reduction of $2.54/tDM or $19.06/ha was observed.
- Establishing ryegrass (Paddock 2) compared to established ryegrass (Paddock 6) yielded 44.50 kgDM/ha/day compared to 42 kgDM/ha/day, translating into GPWUI of 1.33 and 1.26 tDM/ML respectively.

Irrigation system evaluation

Table 2 Reported irrigation system evaluation metrics

Evaluation year	System capacity (mm/day)	Co-efficient of uniformity (%)	Distribution uniformity (%)	Application V panel (%)	Pump efficiency (%)	Energy use (kWh/ML/m)	Average application rate (mm/h)	Centre pressure (%)	End pressure (%)
2022	13.9	89	91	+3	94	3.3	82	+47	-20

- The groundwater bore pump is old and moves high volumes of water from a minimum of 20m depth, as the major farm irrigation supply. It is highly probable that the groundwater pumping costs are higher than the pumping cost from dam to pivot. Significant gains in energy costs for the entire farm operation can be made here, although it was difficult to isolate the power use of the bore pump, which shares a meter with the dairy. The water is also used to supply other irrigation systems across the farm.
- The evaluated pump was responsible only for the *dam to centre pivot transfer of water.* The pivot and pump system components are designed to be both energy and water efficient, which was confirmed by theoretical and actual tests (91% vs pump curve of 78%) and very well matched to flow and pressure delivery required.
- The efficiency of the pump (3.3 kW/ML/m head) was within the industry benchmark. The pumping costs were determined to be $36/ML based on the 23.3 cents/kWh tariff.
- System capacity of 13.9mm is high considering peak daily ETo for the Yarram region is less than 9mm/day. During the summer peak water demand for ryegrass, the pivot would be required to irrigate 15.5 h/day to maintain pasture water requirement, which can be done during off-peak power periods.
- The Distribution Uniformity (DU) of the pivot is excellent, providing consistency of application under the pivot. Of the 174 sprinklers, a small number on the very end span of the pivot were partially blocked with organic material, so regular flushing is recommended to prevent high-pressure losses between the pivot centre and end span.
- Reduced pressure requirement at the pivot centre allows the variable frequency drive (VFD) on the pump discharge to be set at lower pressure. The VFD was operating at 3.9 (62 psi) bar and could be closer to 3.1 bar (45 psi) if the pressure losses in the pivot are rectified. Reducing the discharge pressure by 8M would save almost 26 kW/ML pumped, which would reduce power costs by around $350 per season, assuming the pivot area is irrigated with around 2.5 ML/ha (Season 3) and power costs remain at 23 cents/kWh.

Reference group support

- The site was supported by a small group of local farmers and service providers at project establishment when the site questions were determined.
- In Seasons Two and Three the SIP2 Reference Group was integrated into the Yarram Discussion Group, coordinated by GippsDairy.
- There were challenges in engaging local farmers, with Covid restrictions throughout most of the operating months, favourable irrigation seasons that lessened the priority of irrigation management and changes in both technical and extension role responsibilities. The final field event was the most successful activity, where irrigation was embedded into other seasonal topics at an event held on a local farm.
- There were two field days totalling 35 attendees, one workshop on IrriPasture with 10 attendees and three reference group meetings conducted online to a total of 25 attendees.
- Dairy irrigators across Gippsland were kept informed about the site's activities and data outputs regularly through the integration of the two Gippsland SIP2 sites into AgVic's *Weekly Irrigation Requirement Reports*. A total of 28 reports were emailed directly to 182 recipients each week.

MORE INFORMATION

Cath Lescun, Dairy Australia
National Soils and Irrigation Lead
E: Cath.Lescun@dairyaustralia.com.au

dairyaustralia.com.au/smarterirrigationforprofit

smarterirrigation.com.au

Dairy Australia Limited ABN 60 105 227 987
E enquiries@dairyaustralia.com.au
T +61 3 9694 3777
F +61 3 9694 3701
dairyaustralia.com.au

3513.9 | Jan 2023