SMARTER IRRIGATION FOR PROFIT 2

Bega Dairy Optimisation Site

TECHNICAL REPORT

SITE BACKGROUND

Dairy Optimisation Site Coordinators: Kym Revington and David O'Donnell

Owner: Will Russell

Location: Jellat Jellat in the Bega Valley, Far South Coast, DairyNSW Region, NSW, Australia

Herd size: Approximately 300 Illawarra cows, all-year-round milking

Irrigation site and set-up: 20-year-old, 5-span centre pivot (25ha) or combined bike-shift, k-line and travelling gun irrigators

Water supply: River pump

Irrigation season: Year-round, annual ryegrass sown until permanent kikuyu becomes dominant in approximately December.

The site is typical of the granite-derived sandy loam soil of the Bega Valley. These soils contain a sand-gravel layer. Irrigation is used to supplement rainfall.

September–February was chosen to represent the region's peak irrigation season when farmers aim to maximise and extend ryegrass production and transition into the summer kikuyu season.

The challenge is to maintain optimal soil moisture within a relatively small readily available water (RAW) zone of approximately 17mm. The topography of a high hill (centre tower) to low flats (end span) across the area covered by the centre pivot is also a major challenge.

Site questions

- What is the optimal timing of irrigation to avoid a green drought?
- What is the optimal irrigation schedule to maintain RAW across the soil types of the irrigated area?
- What is the optimal application rate for a centre pivot irrigation system on typical Bega Valley soils and kikuyu/ryegrass pastures?
- What are the potential yield and water/energy efficiencies with variable rate irrigation (VRI)?
- Which is the easiest and most accurate water balance tool: SWAN Systems Weatherwise or IrriPasture?

Key messages

- Soil moisture monitoring and irrigation scheduling using tools, such as SWAN Systems Weatherwise forecasts, is highly recommended for irrigators of the Bega Valley.
- Irrigation schedules that deliver regular, moderate application rates are best suited to the dominant soil type and local climate of the Bega Valley.
- Pasture production can be improved with more uniform application of irrigation water, particularly at the top of hills.

Australian Government
Department of Agriculture, Fisheries and Forestry

Dairy Australia

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- Improved knowledge and understanding gained through the Smarter Irrigation for Profit Phase 2 Project (SIP2) are transferable to other irrigated areas of both the site farm and other irrigated dairy pastures and crops of the Bega Valley region.

Technologies and strategies used

- Three 40cm EnviroPro® capacitance probes with Wildeye® loggers and telemetry were installed to represent the varying soil characteristics (1: North – average, 2: South – dry, 3: East – wet). An EM38 soil survey was conducted in 2019 and the North probe was used to inform irrigation decisions because it was most representative of the soil conditions under the centre pivot. The gravel layer commenced at approximately 25cm down the soil profile, so summed graphs using 10cm and 20cm logged data were the most accurate.
- Two rain-gauges were installed: one dryland and one under the centre pivot.
- The tools most used and valued by Will Russell and reference group members were:
  - Soil moisture monitoring using the EnviroPro®/ Wildeye® equipment
  - SWAN Systems Weatherwise forecasts.
  - Pasture.io to record and manage pasture decisions.
- IrriPasture was used across three seasons, primarily by the site coordinator:
  - **Pros:** simple to use under most conditions and beneficial for identifying when irrigation was less than estimated pasture water use, using the ETc graph.
  - **Cons:** reports that irrigation is needed when the calculated water budget drops below field capacity (a zero deficit of soil moisture) based on the simple difference between rainfall and irrigation in and evapotranspiration (ETo) out. The North probe's Wildeye® summed graph and IrriPasture's water budget graph (same period after significant rainfall) gave conflicting information. IrriPasture assumes a free draining soil and resets to field capacity within 24 hours of the calculated budget exceeding field capacity. Often, as the irrigation season approaches or after a significant rain event, this calculation does not align with actual soil moisture. Instead, the soil moisture remains at or near field capacity for longer due to lateral or capillary flow of water into the profile or, if after a large rainfall event, drainage of a saturated profile takes longer than 24 hours.

Findings

Table 1 Seasonal metrics results

Production	Season One	Season Two	Season Three
Growth rate (kgDM/ha/day)	N/A	56.00	67.28
GPWUI (tDM/ML) rainfall and irrigation	N/A	1.49	1.72
Energy per irrigated ML (kWh/ML)	363.33	350.20	335.41
Energy per tonne DM (kWh/tDM)	N/A	95.00	20.72
Energy used per ML irrigation per m head (kWh/ML/m head)	4.06	3.91	3.75
Costs	**Season One**	**Season Two**	**Season Three**
Water costs per tonne DM ($/tDM)	N/A	$12.12	$2.80
Energy costs per tonne DM ($/tDM)	N/A	$12.99	$2.64
Energy costs per ML water ($/ML)	$52.00	$47.87	$42.76
Energy costs per ML irrigation per m head ($/ML/m head)	$0.58	$0.53	$0.48
Total cost per tDM ($/tDM)	N/A	$25.10	$5.45
Total cost per hectare ($/ha)	$216.64	$253.04	$65.94

Figure 1 Season Two

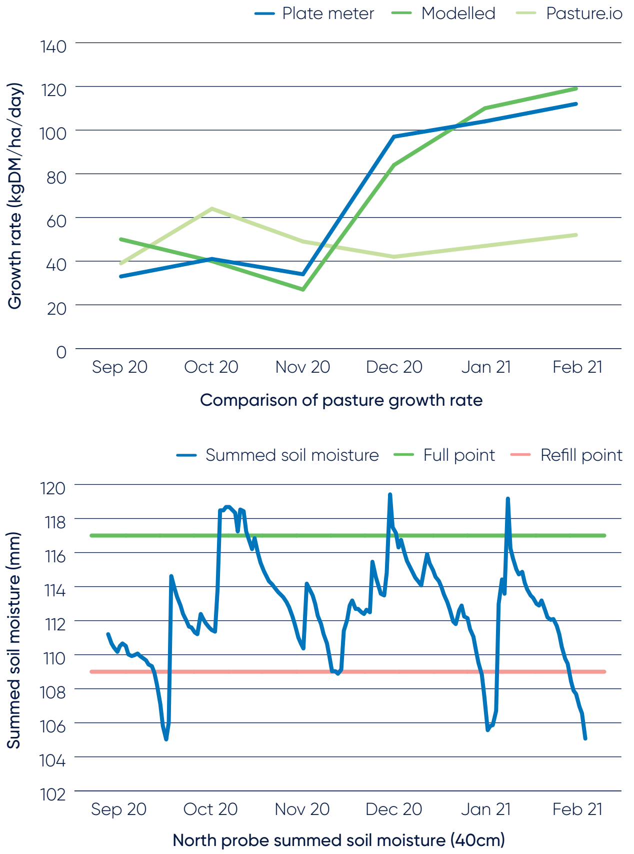
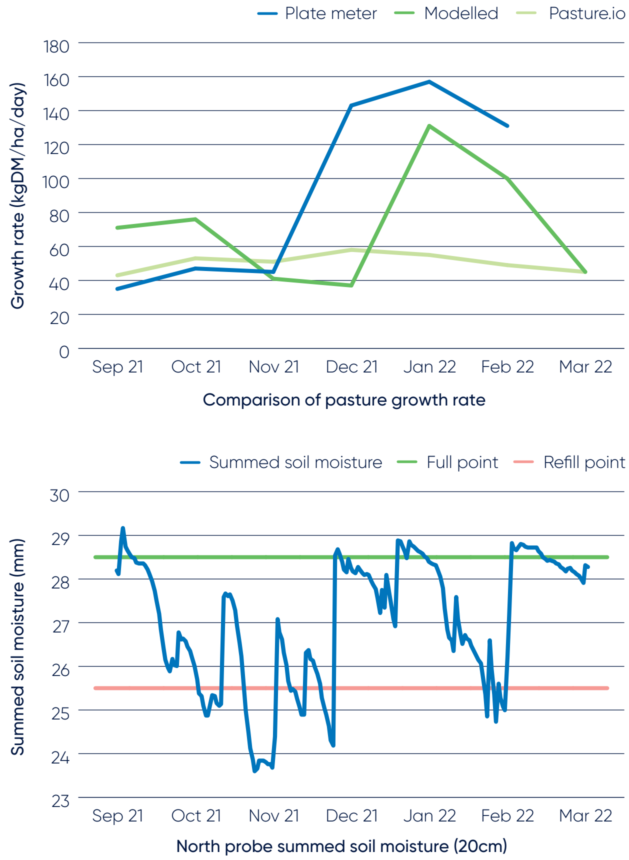
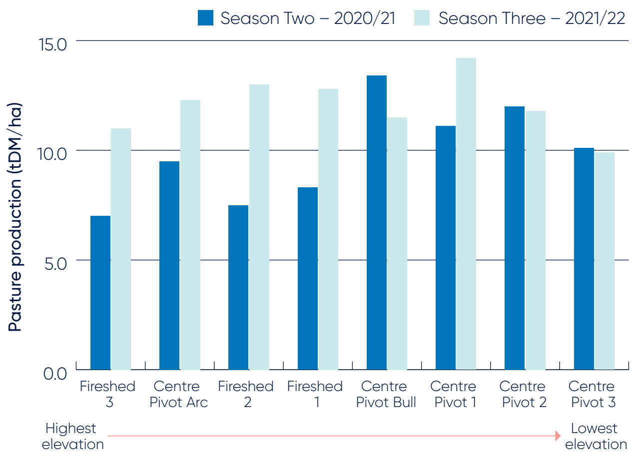


Figure 2 Season Three



- Results were highly influenced by seasonal conditions, with Season One being an extremely dry spring/summer (23% water applied was rainfall with irrigation ceasing due to no allocations mid-summer) compared to Seasons Two and Three being extremely wet (86% and 97%, respectively, of water applied was rainfall).
- Energy efficiency improved from 4.06 to 3.75 kWh/ML/m head over the three seasons, which reduced energy costs by 17%.
- In Seasons Two and Three, irrigation commenced slightly earlier after rainfall than in past practice to maintain soil moisture within the determined RAW zone and to avoid a green drought throughout the season (Figs 1 and 2). *Note: The summed graph for Season Three (Fig. 2) uses 0–20cm rather than 0–40cm as used in Season Two (Fig. 1). The adjusted graph was used by Will Russell in Season Three because it most reflected the observed site conditions in the very wet season.*
- An irrigation schedule that delivers regular, moderate application rates of ~10mm every 36-48 hours during the height of summer suits the typical sandy loam soil and the local climate (ETo rarely exceeding 9mm/day) to maintain the RAW zone and replenish moisture loss from ETo.
- Modifying the irrigation scheduling by monitoring soil moisture data and rainfall forecasts allows the soil moisture level to drop to near refill point, which most efficiently captures and stores rainfall in the soil profile, reducing irrigation inputs and improving water efficiency (GPWUI 1.49 tDM/ML Season Two to 1.72 tDM/ML in Season Three.
- There was a strong alignment between the measured and modelled growth rates in Season Two (Fig. 1). The reduced measured growth rates, compared to modelled, in early spring were attributed to limited nitrogen use. Overall, the site performed only 1 kgDM/ha/day on average below modelling in Season Two and exceeded by 10 kgDM/ha/day in Season Three (Fig. 2). Pasture.io was highly inaccurate for this site, especially during the kikuyu dominant periods.

Figure 3 Pasture production in each paddock under the centre pivot at Jelgowry, Jellat Jellat in Seasons Two and Three



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 (%)
2020	12	88	80	-13	83	3.8	53	N/A	-40

- In Season Two, there was a trend of increasing pasture production with decreasing elevation under the pivot. In addition, the irrigation system evaluation identified poor distribution uniformity (DU), particularly at the higher elevations (hill) under the pivot where the water pressure was too low for the sprinklers, primarily because the required regulator pressure (usually about 15 psi) was close to or higher than the pressure of the water supplied. Season Three was very wet and rainfall constituted >90% of the water applied to the paddocks, which was an opportunity to measure yield with no water limitations (DU approx. 100%). There was a 20% increase in measured yield from 10.1 t DM/ha in Season Two to 12.1 tDM/ha in Season Three (Table 1). The highest gains were in the paddocks at the top of the hill (Fig. 3).

Energy efficiency (kWh/ML/m head, Table 1) appeared to be good, but the pump was operating at a high discharge pressure to compensate for excessive pressure losses in the pivot mainline, resulting in inadequate pressure at the sprinklers.

In Season Two, a new intake screen on the suction pipe was installed to prevent blockages, which helped to increase pump efficiency and reduced associated electricity and maintenance costs. Energy usage reduced from 363 kWh/ML in Year One to 350 kWh/ML in Season Two, equating to cost saving of $4.13/ML.

Low pressure at the sprinklers, especially evident at the higher elevation, affected DU. Achieving DU >90% (excellent rating) was motivated by maximising yield (Fig. 3). The site coordinators evaluated the costs of retrofitting VRI technologies (>$50,000) versus improving the sprinkler pack of an already ageing centre pivot ($7,000) to lower the regulated pressure, improve wetted width, dry wheel packs and result in a more effective end gun. As a result of the SIP2 project costings, the specified sprinkler pack was purchased through the NSW Government's *Coastal Clean Catchments* project. The investment will return a total of $125,000 over 10 years, with less than a 1 year pay-back period. Additional benefits include reduced bogging and maintenance of wheel tracks and reduced waterlogging in areas under the pivot that were deemed to be over-watered.

Energy usage (kWh/ML) was reduced across each season, resulting in a 7.8% reduction in energy use and cost savings of $9.24/ML pumped (coupled with a reduced electricity price) over the length of the project. This is likely due to the new intake screen of the suction pipe, and also higher river levels, which improve the pump's efficiency.

Reference group support

- The site was supported by a small group of local farmers and service providers.
- Local collaborations resulted in five reference group members having irrigation system evaluations undertaken by NSW Department of Primary Industries staff funded by the NSW Government's *Coastal Clean Catchments* project. Reference group farms and other dairy irrigators also had single soil moisture probes installed under the Bega Cheese Pty Ltd *Best Environmental Management Systems* (BEMS) program.
- Both Season One (drought) and Season Three (flooding) resulted in regional conditions that constrained interest in irrigation discussions and reduced time available for farmers to attend meetings.
- Two field days (37 attendees) and two workshops (13 attendees) were conducted in Seasons Two and Three.

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

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