SMARTER IRRIGATION FOR PROFIT 2

Mt Compass Dairy Optimisation Site

TECHNICAL REPORT

SITE BACKGROUND

Dairy Optimisation Site Coordinator: Cathy Ashby

Owner: Ben McHugh

Location: Mosquito Hill, Adelaide Hills, DairySA region, South Australia

Herd size: 330 Jersey cows on a milking platform of 180ha, 22.5ha irrigated

Irrigation site and set-up: 2.5ha paddock under a 12.5ha 4-span centre pivot (10ha of solid-set irrigation using the same water supply and pump)

Irrigation season: September–March/April

In Season One the site had biennial ryegrass/white clover, which achieved a poor gross productivity water use index (GPWUI) of 0.67 tDM/ML (industry benchmark 1–2 tDM/ML) and an average growth rate of 35.55 kgDM/ha/day. Therefore, in Seasons Two and Three the production and water efficiency benefits of an August 2020 sown lucerne crop were investigated, comparing the lucerne dry matter production and water use efficiency to that of ryegrass.

The challenge was to precision apply irrigation to meet the changing water demands of a developing lucerne crop, understanding that irrigating lucerne for optimum yield is very different to biennial ryegrass. In Season Two, the readily available water (RAW) was based on a lucerne rooting depth of 50cm (27mm), which increased in Season Three (36mm) based on a plant rooting depth of 70cm, the depth at which soil moisture monitoring indicated that water draw-down was occurring.

Site questions

- Will water use efficiency and yield be improved by using technology to understand RAW refill and field capacity limits to accurately schedule the timing and rate of irrigation?
- Does growing lucerne as compared to biennial ryegrass improve yield and water and energy efficiency in the central South Australian dairy region?

Key messages

- Changing from a ryegrass to lucerne pasture base requires changes in irrigation management according to soil moisture:
  - Establishing new lucerne stand requires small, frequent irrigation during the rapid development of roots, with adjustments to match the depth of application and rooting depth as roots continue to penetrate down the soil profile in the first season.

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.

- An established lucerne stand requires irrigation applications to match the 70–100cm rooting depth of mature plants. Irrigation scheduling aims for higher, less frequent applications to achieve water penetration, with soil moisture monitoring assessing the effectiveness of these higher applications and determining if further adjustments are required. A double irrigation event is an effective way of applying higher rates of irrigation without runoff loss and to better match system capacity.

- Earlier start-up at the commencement of the season resulted in significant growth rate improvements and soil moisture levels within the RAW zone, although these benefits reduced if ongoing irrigations were scheduled by 'typical' rather than precision practices.
- Over the measured irrigation seasons, lucerne delivered greater yield and improved water and energy efficiencies compared to biennial ryegrass under irrigation. However, a full comparison of the two pasture types should be made over an annual period because lucerne growth rates decline in cooler months whereas ryegrass growth rates improve.
- Established lucerne produced 1.91 tDM/ML compared to the biennial ryegrass at 0.67tDM/ML with the total cost of water and energy reduced to $22.75/tDM from $108.42/tDM.
- System capacity currently limits the area sown to lucerne under the centre pivot. To convert the full 12.5ha to lucerne, the flow rate of the pivot will have to increase and 5ha of the solid-set irrigated land will be needed to meet the peak water demand of the lucerne during the height of summer.

Technologies and strategies used

- Two 30cm Terros-10® probes with Wildeye® loggers/telemetry installed into (1) lucerne study site and (2) fescue paddock for Season Two, with an 80cm EnviroPro® capacitance probe with Wildeye® loggers/telemetry also installed in the same location on the lucerne site in Season Three to reflect the matured rooting depth of the crop.
- Rain-gauge installed (replaced in Season Three due to ongoing malfunctioning).
- Local Mosquito Hill NRM weather Station, located near the farm, used for previous seven-day rainfall and evapotranspiration (ETo) data.
- SWAN Systems Weatherwise used for upcoming seven-day rainfall and ETo forecasts.
- IrriPasture was used to capture irrigation and rainfall conditions on the site and the lucerne RAW for each season (27mm and 36mm).
  - **Pros:** Aligned with the general trends of the lucerne 30cm (Season Two) and 80cm (Season Three) probes and ideal for tracking plant water requirements (ETo) against irrigation + rainfall. Local weather station data is automatically inputted.
  - **Cons:** Ideally in a developing lucerne stand it would be most accurate to be able to change the RAW as the rooting depth developed throughout the first season of growth.
- In Season Two (2020–21), the focus was on establishing the lucerne while balancing the need to maximise yield. From late October the 'typical' irrigation practice for biennial ryegrass was used applying 12.5mm approximately two times weekly, increasing to two to three times weekly in December-January. As a result soil moisture moved above and below the refill point, rising to optimal only with a significant rainfall event in mid-February, and again in late March–early April as ETo declined.
- In Season Three (2021–22) the priority in spring was to further establish the rooting depth of the lucerne and then maximise yield through summer–autumn. A new irrigation schedule was trialled in December after soil moisture monitoring analysis demonstrated water was only reaching 30cm and soil moisture was declining. The strategy was to reduce 'typical' frequency while increasing the rate to achieve a greater depth of application. To reduce the risk of runoff, three times between 25 December and 8 January the pivot was operated twice in a 48-hour period to deliver two 10.5mm applications. However, 'typical' practice was reinstated and both IrriPasture and Wildeye® monitoring demonstrated soil moisture remaining below the refill point, except for a rainfall event in early February.

Findings

Table 1 shows the dry matter (DM) production, water and power metrics for three seasons at Mt Compass. 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 profile in relation to the field capacity and refill points for the same time period as the pasture measurements.

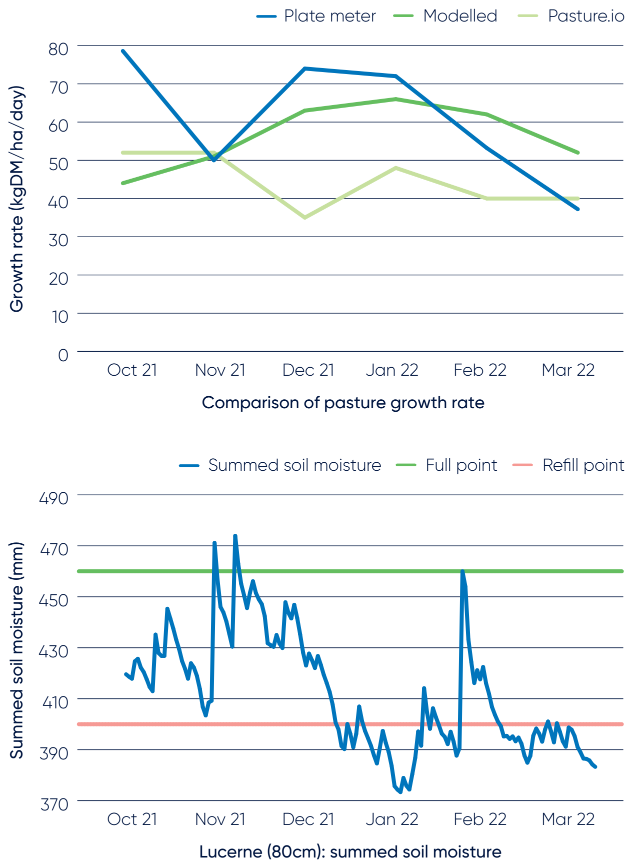
Table 1 Seasonal metrics results

Production	Season One (Biennial ryegrass)	Season Two (Developing lucerne)	Season Three (Established lucerne)
Growth rate (kgDM/ha/day)	35.51	41.67	62.03
GPWUI (tDM/ML) rainfall and irrigation	0.67	1.32	1.91
Energy per irrigated ML (kWh/ML)	367.00	274.30	286.02
Energy per tonne DM (kWh/tDM)	386.00	145.65	84.25
Energy used per ML irrigation per m head (kWh/ML/m head)	7.20	5.38	5.15
Costs	**Season One**	**Season Two**	**Season Three**
Water costs per tonne DM ($/tDM)	0	0	0
Energy costs per tonne DM ($/tDM)	$108.42	$50.25	$22.75
Energy costs per ML water ($/ML)	$103.00	$94.63	$77.23
Energy costs per ML irrigation per m head ($/ML/m head)	$2.02	$1.86	$1.39
Total cost per tDM ($/tDM)	$108.42	$50.25	$22.75
Total cost per hectare ($/ha)	$412.00	$201.00	$258.24

**Modelled yield determined using the Agricultural Production Systems sIMulator (APSIM v7.10) under different irrigation strategies for a range of sowing dates at Mt Compass using 1991–2022 climate data. (Dr James Hill, Dr Matthew Tom Harrison, Dr Ke Liu, Tasmanian Institute of Agriculture).*

Figure 1 Season Two

Figure 2 Season Three



- Within the irrigation season, yield almost doubled and energy/water costs improved when comparing the biennial ryegrass with the grazed lucerne, both establishing and established. The Table 1 data do not provide adequate information to evaluate the benefits of lucerne across the annual growing period, especially in Winter when ryegrass would outperform the lucerne.
- GPWUI achieved in Season Three was within the industry benchmark of 1.91 tDM/ML, which was a great improvement from 0.67 tDM/ML for the biennial ryegrass in Season One, and the total cost of water and energy was significantly lower ($22.75/tDM) than in Season One ($108.42/tDM).
- The lucerne crop achieved a relatively good average growth rate, with room for improvement, especially in mid-Summer to early Autumn in Season Three (Figures 1, 2). In Season Two, the lucerne was developing and would not achieve the modelled yield of an established crop, although the measurements clearly demonstrated that the crop continued to establish well throughout the season (Figure 1), which was the aim. In Season Three, the measured average growth rate of 62.03 kgDM/ha/day exceeded the modelled by 5.67 kgDM/ha/day.
- Season Three start-up was three weeks earlier than in Season Two, resulting in an early season growth rate of 78.6 kgDM/ha/day, which was 45% above modelled yield potential. However, it declined from late November to late December to 50 kgDM/ha/day as soil moisture fell below the refill line, until the double-watering strategy was adopted in late December (74 kgDM/ha/day for a very short period).
- The double-watering strategy should be followed throughout the periods of high ETo to ensure both depth of application and maintenance of soil moisture within the RAW zone. When it was not followed throughout the entire Summer, yield was affected. 'Typical' practice resulted in a decline and it continued downwards, even with a number of rainfall events, for the rest of the season and dropped below modelled from mid-January until measurement finished at the end of March.
- Overall, Pasture.io measured 10% above plate metered measurements in Season Two and 18% below in Season Three.

Irrigation system evaluation

Irrigation system evaluations were conducted at the beginning and end of the project (Table 2).

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 head)	Average application rate (mm/h)	Centre pressure (%)	End pressure (%)
2020	11	91	86	-14	58	4.8	37	N/A	N/A
2022	6*	92	89	-2	59	4.9	38	+24	-19

**One pump supplies the centre pivot and a solid-set system. The solid-set system is 10 ha and requires about 28 hours to apply 20 mm irrigation to ryegrass and white clover. The pivot is 12.5 ha and requires about 24 hours to apply 12.5 mm. As the irrigable area is supplied from one pump, system capacity needs to be calculated using the whole of the area under the centre pivot and the solid-set system. This was not taken into consideration in the 2020 evaluation.*

- The managed system capacity of 5.3mm/day is inadequate to meet the peak water requirements of ryegrass (7.1mm) or lucerne (8.2mm) pasture in January, so pasture productivity is compromised during peak water periods. To improve the managed system capacity, the flow rate could be increased and/or the irrigable area reduced. To increase the capacity to 9.5mm/day, the solid-set system could not be used over summer. If the flow rate of the combined system was increased from the current rate of 15.1 L/second to 20 L/second (1.728 ML/day), a capacity of 9.8mm could be achieved, with only 50% of the solid-set area not being used.
- The efficiency of the pump was determined to be poor at 59%, well below the performance chart of 75%. The potential for improvement via an overhaul was determined to be 8% efficiency, representing a 7% annual saving or $750 annually. Installing a new pump with variable frequency drive (VFD) control from the end of the pivot could be economically beneficial, any investigation must include the requirements for the solid-set irrigation system. It is estimated that up to $1,094 annually (12%) in electricity costs could be saved by replacing the existing pump with a fit-for-purpose pump, with an estimated pay-back of six years.

Reference group support

- This site did not have a continuous reference group supporting activities. An existing 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 the three irrigation seasons by the site coordinator and emailed directly to 24 local farmers and service providers in the site reference group. The reports included:
  - SWAN Systems Weatherwise forecasts
  - ETo and rainfall data for seven-days previous recorded at local weather station
  - Lucerne 30cm (Season Two) and 80cm EnviroPro probes with Wildeye® stacked and summed graphs
  - IrriPasture water budget graph
  - Pasture.io satellite map of current growth rate predictions of the optimisation site and feed wedge graph
  - commentary on the information and its relevance for irrigation requirements and management
  - short item on relevant weather- or irrigation-related issue (e.g. seasonal climate outlooks)
  - promotion of events.
- The local agronomist played an integral role at this site through monitoring pasture growth rates and providing reports and updates to the group after each pasture measure.

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