Dairy Australia

SIP2 Snapshot Series
Using weather forecasts to schedule irrigation

Weighing-up the risk versus reward of applying the next irrigation

KEY POINTS

Dairy irrigators have higher confidence in seven-day weather forecast information today, providing valuable insight into irrigation requirements.

Weather forecasts used in combination with soil moisture monitoring, can assist irrigation managers maintain soil moisture in the readily available water (RAW) zone using rainfall, irrigation, or a combination of both.

Decisions on applying or postponing irrigation can sometimes be difficult. Using freely available weather information, dairy irrigators can make informed decisions to optimise plant growth (avoid dry or saturated conditions) and most effectively use off-peak power opportunities.

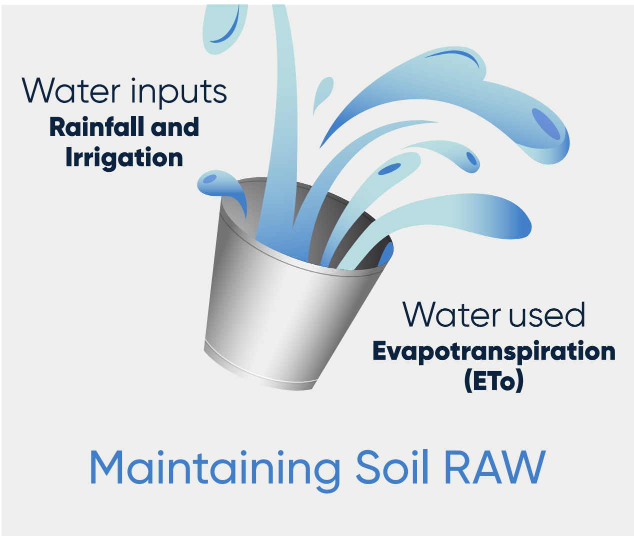
Why use weather forecasts?

Weather forecast data allows dairy irrigators to consider two fundamental factors influencing water input and output from the soil moisture 'bucket', or readily available water (RAW) zone. These are rainfall (mm) inputs and evapotranspiration (ET_0 (mm/day)) outputs (see Figure 1). Armed with this information, irrigators can schedule irrigation to optimise water and power use efficiency, reduce risks associated with under or over watering, and ultimately maximise dry matter (DM) yield.

Whilst not all forecasted conditions prevail, today farmers are growing in confidence about the accuracy of certain weather data sources, allowing them to make an informed decision when weighing-up the risks and benefits associated with when to schedule the next irrigation.

In its simplest form, a water balance method of scheduling irrigation uses the formula:
ET_0 (mm) – effective rainfall (mm) = irrigation required (mm).

Figure 1 The Readily Available Water (RAW) bucket of each soil/plant type is naturally replenished by rainfall and depleted by ET_0. Irrigation makes-up the short-fall when ET_0 outputs exceeds rainfall inputs.



Understanding what is reported

Evapotranspiration (ET_0) is a measure in millimetres per day (mm/day) that quantifies predicted water loss from a reference plant. It considers the effects of sunlight, wind, humidity and temperature.

ET_0 is reported by weather forecasting sources using an actively growing, well-watered grass of 120mm in height as a reference point.

DELIVERING *for* DAIRY

Australian Government
Department of Agriculture, Fisheries and Forestry

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.

When using ET_0 for actively growing crops, such as lucerne, maize, sorghum or millet, the crop coefficient (Kc), a measure of the water use of a plant compared to that of the reference plant needs to be considered. Whilst a stand of grass has a Kc of 1.0, these mature, full canopy crops are likely to have an approximate Kc value of 1.2, meaning they require 20% more water than the reference grass stand reported by the weather forecasting services. Kc values increase as the crop canopy develops.

Crop water requirement (ETc) is therefore determined by ET_0 x Kc of the crop grown

Figure 2 is an example of how weather forecast data is received by subscribers of Swan System's Weatherwise Forecast Updates. The seven-day forecast shows that daily and cumulative ET_0 is much higher than the predicted rainfall. Crop growers need to multiply the reported ET_0 by the current crop Kc.

Figure 2 Weatherwise Forecast Update for Tocal Dairy, Lower Hunter, NSW on 17 August 2022

Date	ET0* (mm)	Chance of rain (%)	Rain range (mm)	Rain estimate (mm)	Temp range (°C)	Avg R. Humidity (%)	Avg Wind Speed (km/hr)
Wed 17 Aug	2.4	5	<1	0	5–20	75	8
Thurs 18 Aug	3.2	< 5	<1	0	6–22	71	14
Fri 19 Aug	3.6	20	<1	0	9–21	66	17
Sat 20 Aug	2.6	10	<1	0	6–18	67	9
Sun 21 Aug	2.5	10	<1	0	6–19	74	9
Mon 22 Aug	2.9	<5	<1	0	5–21	72	11
Tues 23 Aug	3.4	40	0–1	1	9–20	61	15
Total	**20.6**			**1**			

What is my current soil moisture status?

A water balance approach means very little without knowing the size or current soil moisture status of the RAW 'bucket'. RAW (mm) is the term used for the water available within the effective rooting zone of a crop or pasture that is easily extracted by a plant without impacting its growth.

Soil characteristics and plant rooting depth impact the size of the RAW 'bucket' (refer to *Determining Readily Available Water from Soil Texture Information*). Once determined, RAW provides the upper limit (field capacity or full point) and lower limit (refill point) of the ideal soil moisture zone to target when irrigating (see Figure 3). Importantly, RAW is likely to change during the irrigation season. For example, soils that have been saturated may become compacted, reducing the number and/or size of pores that hold water available to plant roots, and potentially restricting their penetration, reducing the RAW. Conversely, developing roots will increase the RAW over the lifespan of a newly sown pasture or crop as they begin to penetrate deeper into the soil profile. Water is needed and extracted at greater depth.

Soil moisture monitors (refer to *Using Soil Moisture Monitoring to Schedule Irrigation*) provide location specific real-time data on the status of soil moisture, reported against the determined field capacity/full point and refill point (see Figure 4). As this provides the baseline for appropriate response to weather forecast data, soil moisture monitoring should ideally be used in combination with a water balance. As you apply irrigation or as rainfall events occur, monitoring allows you to assess the effectiveness of the water inputs and along with the most current weather forecast assists to inform your irrigation scheduling.

Figure 3 Using weather forecast data to inform scheduling of irrigation to maintain soil moisture within the RAW is the aim. This is the zone in which plant growth is optimised.

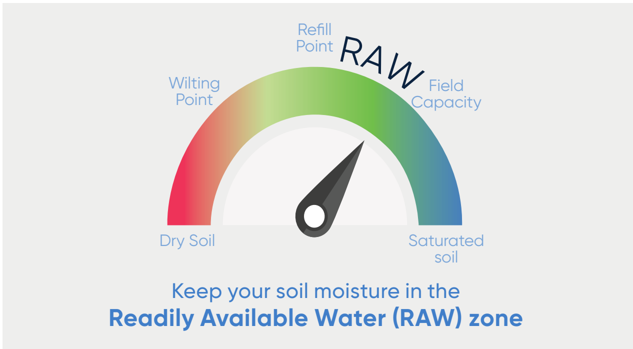
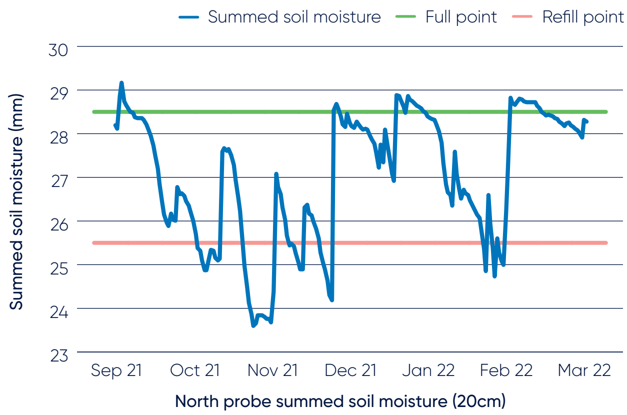


Figure 4 A typical summed soil moisture graph reported via smartphone apps or PC platform. A summed graph is a cumulative total of all 10 cm increment sensors of the probe. 40cm probes are typical for pastures and 80cm-100cm for crops.



SIP2 CASE STUDY

Bega Optimisation Farmer of the Smarter Irrigation for Profit phase two (SIP2) Project, Will Russell, quickly developed his skills to use soil moisture monitoring and forecast data to change the frequency and rate of his applications. He started irrigation earlier after rainfall events in the season of 2020-2021 and postponed irrigation when rainfall was forecast in the wet 2021-2022 season.

Will learnt that allowing soil moisture levels to drop nearer the refill point, when the Swan Systems Weatherwise Forecast Update predicted significant rainfall in the next seven days allowed him to most effectively capture and store that rainfall in the soil profile, reducing irrigation inputs. This strategy drove improvement in water use efficiency. He improved his Gross Production Water Use (GPWUI)* Index from 1.49tDM/ML to 1.72tDM/ML in one year.

His yield also increased by 20% whilst reducing his energy costs by 17% in two years.

**GPWUI is used by the dairy industry as an indicator of total water use efficiency (irrigation + effective rainfall). Under the 'Australian Dairy Sustainability Framework' the industry has committed to improving water use and water productivity to utilise 2tDM/ ML by 2030.*

How do I use this information to schedule irrigation?

Water applications (irrigation or rainfall) above the determined RAW 'bucket' will result in deep drainage or run-off losses. Weather forecasts that predict the ET_0 minus effective rainfall higher than the determined RAW will require irrigation applications over a number of events in a seven-day period. Using Figure 4 as an example, the last soil moisture data point recorded shows that levels are ideal, sitting just under field capacity/full point. At this time, the weather forecast demonstrated a cumulative ET_0 of 28mm for the coming seven days, with 5mm of rainfall, but 3mm of effective rainfall. (See definition of effective rainfall in box below.) To maintain this ideal RAW level, approximately 25mm (28mm minus 3mm effective rainfall) needed to be scheduled for application in the next seven days. Given soil moisture is sitting in the upper limits of ideal, the farmer decided to use three application events of 10mm over ten days, allowing him to apply during off-peak power periods whilst ensuring his applications did not overfill the RAW 'bucket'. Whilst in this scenario it was possible to apply the required irrigation using the available off-peak tariff, research has found that the economic benefit of applying peak tariff irrigations to optimise yield (home grown feed) outweighs the power savings made by ceasing irrigation when soil moisture is not yet ideal.

Effective rainfall is the amount of rainfall that is likely to penetrate into the soil to increase soil moisture. A certain amount is deducted from the total rainfall as allowance for the water immediately lost through evaporation on the surface, dependent upon wind and humidity conditions. Typically, the first 2mm of rainfall is considered not effective.

When am I likely to delay an irrigation?

Weather forecast data is valuable in indicating when there may be potential to postpone an irrigation event to avoid saturation and unnecessary water and power expenditure. Using Figure 4 as an example, if the forecast was for a cumulative ET_0 of 28mm and rainfall of 30mm, irrigation is not needed. However, it is always best to be prepared to irrigate. Should the rainfall event not eventuate, soil moisture would decline over the seven days to below the refill point, and irrigation would need to commence at the back end of the period given the RAW 'bucket' is only 17mm. The decision about when to irrigate must also consider the capacity of the irrigation system (refer to ***Irrigation Guide – efficient water use for dairy*** ***Insert short link?***). Postponing irrigation too long can result in long-term soil moisture deficit if the capacity of the system cannot keep-up with ET_0 loss or may force a scenario of irrigating during costly peak power periods.

When am I likely to bring forward an irrigation?

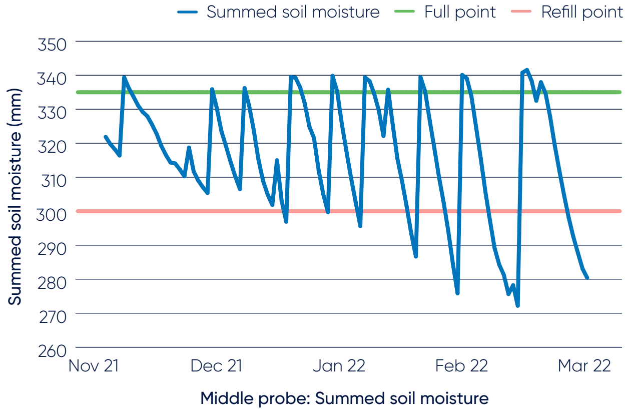
Weather forecast data provides valuable information at the beginning of the season on predicted rising ET_0, and during the irrigation season on long-term high ET_0 events. Both situations will call for irrigation to commence if comparable rainfall is not forecast.

Starting irrigation earlier at the beginning of the season has been one of the biggest changes in recent years as dairy irrigators have adopted both weather forecast and soil moisture monitoring tools. Soil moisture monitors reflect that as ET_0 and soil temperatures increase, stored moisture coming out of the wetter months is lost rapidly, though this is not necessarily demonstrated visually above the ground (refer to *Irrigating to avoid the Green Drought*). In this situation, irrigation should commence to maintain soil moisture in the RAW, especially if weather forecasts indicate ongoing similar conditions.

As higher ET_0 are forecast over prolonged hotter periods, dairy **spray irrigators** will need to increase the frequency or rate of their irrigations to maintain RAW. The decision on which strategy to use must consider the capacity of the irrigation system and depth of application needed to ensure water infiltration to the required rooting depth of the pasture/crop.

With less flexibility on rate applied, dairy **surface irrigators** need to consider bringing forward their water order to ensure that bottom areas of bays are irrigated prior to the refill point of RAW being reached. For this reason, it is good practice to have soil moisture monitors located at several points along the bay.

Figure 5 Tongala SIP2 Optimisation Site 'middle bay' soil moisture monitor schematic graph for season 2021-2022. The field capacity/full point and refill point lines are positioned to reflect a mature, but not final, maize crop rooting depth of 90cm.



Irrigating Crops with surface applications-balancing frequency as ET_0 and RAW increase

Figure 5 shows the 'middle bay' soil moisture monitor graph from the SIP2 Tongala Optimisation Site (Murray Dairy region, Victoria) in the season of 2021-2022. It demonstrates that applications of 50mm were applied at approximately the same interval across the season. When the maize crop was developing, RAW was well maintained as the plant roots developed and cumulative ET_0 was lower in late spring/early summer. At this point, there was opportunity to consider postponing applications by a number of days to allow the RAW 'bucket' to deplete more fully in this area of the bay. In mid-summer, application rate and frequency were spot-on. With little rainfall, rising ET_0 loss was met adequately by applications. However, deeper into summer during the silking stage of crop growth with ET_0 at its peak, insignificant rainfall, full rooting depth to 1 metre and high Kc values (full canopy cover), applications were timed too late for this area of the bay. Ideally, the last three applications were required approximately six days earlier as soil moisture declined beyond the refill point.

Conclusion

The two most important data points needed for irrigation scheduling is forecasted rainfall and ET_0. A simple water budget is a useful tool but used in combination with soil moisture monitoring and the RAW for each soil and plant type under irrigation provides greater irrigation precision. By using forecast information, irrigators have the data necessary to determine start-up or vary the rate and frequency of application to ensure soil moisture remains in the optimal soil moisture range for maximising plant growth.

What are dairy irrigators using to schedule irrigation using weather data?

- Swan System's **Weatherwise Forecast Updates** are emailed daily to subscribers for free. A simple table outlining a seven-day forecast for ET0 and rainfall that is based upon modelling using a 6x6km grid. Register for this service at **swansystems.com.au**
- **Bureau of Meteorology (BOM)**, Agriculture Services, provides seven-day rainfall forecasts, longer-term rainfall forecasts (i.e. three-month rainfall ranges) and historical rainfall and ET0 data. Requires a more manual approach to search for the data needed. Access this service at **bom.com.au**
- **IrriPasture** has been developed specifically for the irrigated systems of the Australian dairy industry. It is an online, smartphone accessible, water budget and irrigation scheduling tool. The tool is FREE to access and use. IrriPasture uses soil characteristic and pasture/crop data, together with daily weather data from the BOM and appropriate local weather stations (where available) to determine a water balance for selected irrigated site/s. The graphs, tables and figures of IrriPasture are presented in an easy-to-read dashboard to assist irrigation scheduling decisions. Access this tool at **irripasture.com** (User Guide: **irripasture.com/assets/IrriPasture_user_guide.pdf**)
- **IrriSAT** is a weather-based irrigation scheduling and crop benchmarking tool that uses satellite images to determine a crop coefficient (Kc) at the paddock scale to provide a seven-day forecast of crop water use. Access this tool at **irisat-cloud.appspot.com**
- **Agriculture Victoria** provide a *Weekly Irrigation Requirement* email service that outlines seven-day previous and forecasted information for irrigators. Register for this service at **extensionaus.com.au/irrigatingag**

About Smarter Irrigation for Profit

Dairy Australia's Smarter Irrigation for Profit research, development and extension project was designed to help farmers across Australia make better irrigation decisions which improve water use efficiency and lead to greater profit. Smarter Irrigation for Profit was a partnership between the dairy, cotton, sugar, rice and grain sectors, supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit program and each of the industries involved.

For further information go to
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

3513.14 | Apr 2023