Steps to making efficient use of water

Findings from the "Sustainable dairy farm systems for profit" project

M5 Project Information Series - Studies on Mutdapilly Research Station and subtropical dairy farms 2001 to 2005

Mark CALLOW and Sarah KENMAN

*edited by **Anne CHAMBERLAIN***

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OVERVIEW

EFFICIENT use of rainfall and irrigation water is vital for the future viability of dairy farms in Australia's subtropical dairy region.

At the point of deregulation in 2000, the industry estimated that dairy farms in the region needed to at least double milk output within 10 to 15 years to remain viable.

A key to making that 'leap' is for farms to maximise (and utilise) the production of homegrown forage with the water that is available – both rainfall and irrigation.

To do that, farm managers need to be clear about what efficient use of water is, how it can be 'monitored', and the steps that can be taken to improve their use of this natural resource.

In an era of highly variable, lower than average rainfall, and limited irrigation water supplies, dairy farmers in the region may feel sceptical about the potential for improving forage and milk production. However, improved water use could be the key to the way forward on their farms.

In the low-rainfall, low water-availability period between September 2001 and August 2005, the *Sustainable dairy farm systems for profit* project made some positive findings about improving the use of limited water supplies, and greatly improving milk output from homegrown forages.

This recent project adds to earlier work in the *Rural Water Use Efficiency Initiative*, which found great improvements by minimising losses between the pump and the paddock.

KEY MESSAGES

THE benchmark for milk yield from homegrown forage per megalitre (ML) of water is 1,100 litres milk/ML water for raingrown farms and 1,400 litres/ML for irrigated farms.

SOME forages are much better than others at converting water into fodder for cows.

- Tropical species are two to three times as efficient as cool-season species.
- Crops can be twice as efficient as pastures.
- A double-crop of short-rotation annual ryegrass followed by a summer forage crop of sorghum or maize produced the highest forage yield for the least amount of water.

FORAGES have very different water requirements.

- Irrigated forage sorghum can produce 13 to 19 tonnes DM/ha from 5 megalitres.
- Irrigated maize requires a minimum of 6 megalitres, applied strategically over its growing season, but will yield more than 20 tonnes DM/ha.

IRRIGATION timing and volume need to be adjusted throughout the growing season to meet plant requirements.

- For example, ryegrass requires the least amount during autumn seedling establishment when plants are immature and evaporation is low. During spring, water application needs to double to meet plant growth requirements and higher evaporation losses.

FINE tuning grazing and fertiliser management can greatly improve water-use efficiency.

Queensland Government
Department of Primary Industries and Fisheries

INDUSTRY BACKGROUND

IN many dairying areas of Queensland and northern NSW, rainfall is insufficient and too erratic to sustain forage growth year-round. Supplementary irrigation is a vital part of dairy production on many farms in the region – substantially boosting production of homegrown forage and for growing high-quality temperate forage species for winter feed.

However, the true costs and returns of irrigation, and optimum irrigation timing and application rates are not well defined.

Irrigation has traditionally been scheduled on the basis of a set period of time between irrigation runs – usually dictated by the speed with which the equipment can cover the entire irrigation area. Little consideration has been given to plant water requirements – which are different for different species, for different stages of plant growth, for different grazing and fertilizer regimes, and for different environments and soils.

With increasingly variable and below average rainfall, it is also vital to understand how to maximise use of water from rainfall.

Some Rules of thumb

- 1 megalitre (ML) = 1,000,000 litres
- 1 litre of water applied evenly to 1 square metre will water to a depth of 1 mm
- 10,000 litres will water a hectare to a depth of 1 mm
- 100 mm (4 inches) will apply 1 ML/ha
- To water a hectare to 300 mm (30 cm) we need to apply 3 ML/ha

What is water use efficiency?

Water use efficiency is the ratio of production (which can be milk yield, pasture or crop yield, financial return etc) per unit of water.

Water use efficiency of milk production from homegrown forage:

Total litres of milk produced from homegrown forage (total milk - milk from purchased forage) divided by rainfall + irrigation on milking area.

EXAMPLE:

An irrigated forage system of annual ryegrass and crops produced 650,000 litres of milk from forage from the farm. Total water received as effective rainfall and irrigation was 590 ML.

Water-use efficiency for milk production

= 650,000 ÷ 590 = 1, 100 litres milk/ML water.

Water use efficiency of forage production:

Total dry matter yield ÷ rainfall (for fallow plus forage growth period) + irrigation.

EXAMPLE:

An annual ryegrass crop yielded 9,200 kg dry matter/ha (9.2 tonnes DM/ha). Total water received by the crop was 526 mm or 5.26 ML/ha.

Water use efficiency of forage production

= 9.2 ÷ 5.26 = 1.75 tonnes DM/ML or 17.5 kg/mm.

Improving water use efficiency

Water use efficiency can therefore either be improved by:

1. Increasing the amount of production, OR
2. Reducing the amount of water applied.

1. **Increasing production.** Effective management practices include choosing more water-efficient forage species; single cut rather than multiple grazings; optimum timing and conditions at establishment; improved grazing management for maximum growth; optimum use of fertilizer; optimum growing techniques; cultivation and fallow management; double-cropping; forage conservation to improve forage utilisation and to make maximum use of high-growth conditions.

2. **Reducing water application.** Effective management might include matching water application and timing to plant needs; rainfall, evaporation and soil moisture monitoring; checking and correcting water losses from pumps, lines and equipment; checking and correcting irrigation distribution uniformity; reducing water losses to wind, evaporation, and deep drainage; improving soils to increase their water retention capacity.

Making maximum benefit of rainfall

Use your rain gauge. Knowing how much rain has fallen will help plan irrigation. A fall of 25 mm over 4 hectares has applied 1 ML. A maximum of 20% of the rain will be retained, after losses due to runoff, evaporation, deep drainage, poor infiltration, or extraction by weeds. Light frequent falls on soils with good ground cover are likely to provide most of the water to the root zone.

Techniques to make maximum benefit of rainfall include maintaining soil cover; high soil organic matter; mulching; encouraging strong root development and using deep-rooted crops (like plantain and chicory); minimising moisture loss to weeds; gypsum as a soil conditioner if required; soil moisture monitoring.

Incorporating rain into the irrigation schedule saves water and electricity costs. If an irrigation run usually puts on 50 mm of water, and there has been 15 mm of rain – then you may only need a top up of 35 mm.

How much water can your soil hold?

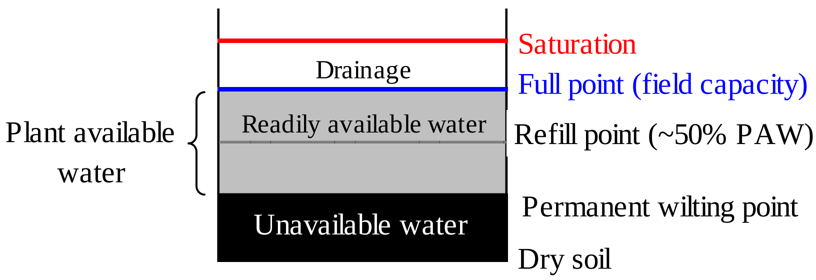
- Full Point (Field Capacity) is the maximum amount of water a soil is capable of holding. Once the soil is full, additional water will be lost through runoff or deep drainage, see *Figure 1*.
- Refill Point (Onset of stress) is the point at which soil moisture has declined to the point of stressing the plant and active growth stops. Time to irrigate.
- Permanent Wilting Point is the soil moisture content at which the plant has wilted and cannot be revived by rainfall or irrigation.
- Plant Available Water is the amount of water between Full Point (Field Capacity) and Wilting Point – the total amount of water available to the plant.
- Readily Available Water is the amount of water between Full Point and Refill Point – the amount of water the plant can readily use before growth is affected.

Irrigation should aim to replace the Readily-Available Water content of the soil, to avoid over or under watering. The less Plant Available Water a soil holds, the more frequently it needs to be irrigated. Typical Plant Available Water figures for a range of soil types are presented in *Table 1*.

TABLE 1. TYPICAL plant available water for a range of soil types.

Soil type	Plant Available Water (mm/m)
Cracking clay	150-250
Clay loam	150-180
Loam	150
Sandy loam	115
Sand	60

Figure 1. SOIL water terms.



Calculating root zone plant-available water

The plant-available water will vary according to soil type and the effective root zone – which varies with forage type and stage of growth.

EXAMPLE:

Irrigated annual ryegrass during spring will have an effective root zone of 70 cm depth in a cracking clay soil.

Root zone plant - available water

= 0.7 x 200 = 140 mm

Measuring the amount and rate of water used

Measuring soil moisture at different depths has proved an excellent indicator of plant water use and requirements.

Equipment like the EnviroSCAN and Diviner electronically measure soil moisture, and provide graphs of soil moisture readings indicating when the soil profile is full, the pattern of plant water use through the day and after grazing and irrigation, and the onset of plant stress.

There are also simple manual techniques for assessing the level of soil moisture – including a ‘dig stick’ which is hammered into the soil, to withdraw a soil sample for inspection for root depth and soil moisture, and a push rod which gives an indication of how far water is below the surface.

The rate of water use can also be estimated from weather-based methods including evaporation pans, knowledge of crop growth, and their crop coefficients.

LESSONS FROM THE M5 PROJECT

DAIRY farms in Queensland and northern NSW have used many strategies over the past five years to compensate for lower margins, low rainfall and reduced irrigation water supplies.

Working alongside commercial dairy farms during the same period, a project at Mutdapilly research station has been testing some of the possibilities and limits of intensifying current farming systems – to define and demonstrate profitable dairy farm systems for the subtropical region.

From September 2001 to August 2005, the farmlets study – part of the *Sustainable dairy farm systems for profit* (M5) project - monitored the production and economics of five different dairy farming systems – ranging from a simple raingrown system based on tropical pastures, to a full feedlot based on homegrown silage crops including lucerne, maize and barley, with the herd milked three times a day.

Mutdapilly Research Station farmlets

To test out the potential of the five farming systems, five farmlets were set up at Mutdapilly with higher stocking rates and higher levels of concentrates than the industry average. Descriptions of the farmlet models are shown in *Table 2* and *Table 3*.

TABLE 2. THE PHYSICAL farmlet models at Mutdapilly Research Station.

Farmlet	Description	Calving pattern	Stocking rate head/ha	Milk production targets
M1	Raingrown pasture	100% spring	1.9	7,040 (L @ 305 days)
M2	Limited irrigation pasture	50% spring 50% autumn	2.8	6,560
M3	Limited irrigation crops	30% spring 70% autumn	1.4	7,300
M4	High irrigation pasture and crops	30% spring 70% autumn	2.8	7,100
M5 feedlot	Feedlot	All year round	4.3	9,650

During the four years of data collection, the farmlets faced similar constraints to commercial farms – below average rainfall, restricted water use and high commodity prices.

Detailed measurement and recording from the farmlets was supplemented by information from companion commercial farms and from QDAS figures for the same period.

The five farmlets all had two goals – to obtain a 10% return on assets (RoA), and to achieve 600,000 litres of milk per labour unit.

TABLE 3. THE FEEDBASE of the 5 physical farmlet models.

Farmlet	Off farm feed (tonne DM/cow) *	Winter forage	Summer forage
M1	3 t Concentrate 1 t hay/silage	Oats	Rhodes grass
M2	3 t Concentrate 1 t hay/silage	Ryegrass	Rhodes grass
M3	3 t Concentrate	Ryegrass, oats, lucerne	Forage sorghum, lablab, lucerne
M4	3 t Concentrate	Ryegrass, prairie, fescue	Lucerne, forage sorghum
M5 feedlot	3 t Concentrate	Maize, lucerne and barley silage	

* Concentrate includes grain, protein meals, minerals and molasses.

NB. The 20-cow farmlets were managed under research station conditions and in the low-rainfall Mutdapilly environment, so results cannot be directly extrapolated to commercial farms across Queensland and northern NSW. However, the farmlets project does indicate potential ways forward for similar farming systems in the region.

Water use studies

THE water-use efficiency aspects of this project aimed to define the different water requirements of a range of crops and pastures, at different stages of growth, under different management regimes – so that farmers could match irrigation timing and volume to the needs of specific pastures and crops, and maximize forage yield and quality. With limited water available, they could also decide ahead which species were most likely to produce more dry matter and more milk from the water available.

The project also aimed to compare the water-use efficiency of the different farming systems, and to define best water and irrigation management for optimum forage yield and quality – including the effect of timing and amount of irrigation on plant growth.

Irrigation scheduling was consistent across all farmlets. Irrigation water was restricted to 6 ML/ha/year.

Individual studies undertaken included

- Preliminary evaluation of the water-use efficiency of 10 forage species in subtropical southeast Queensland (2001-2002 plot studies).
- Determining the response of forage quality and yield of selected forages to irrigation and nitrogen fertilizer (2001 to 2003 plot studies).
- Comparing the water-use efficiency of milk production and forage production of the five common subtropical farming systems (2001 to 2005 farmlet study).
- Testing the efficiency findings on larger scale (2002-2003 Farm system companion farms).
- Determining the water-use efficiency of milk from homegrown forage on 13 commercial farms (2005 to 2006).

The final outcome will be technology and tools to guide dairy farmers towards the best combination of pasture and crop species for their farm, and how to make maximum profit from irrigation water and rainfall.

Companion farm experiences

THE project assessed the ‘real’ expansion opportunities for the subtropical dairy industry; implications for the farm family; and longer-term sustainability by incorporating commercial farms into the project. 22 farms became involved as companion farms, representing a broad cross-section of the subtropical dairy industry’s location, farming style and herd size. There were 6 companion farms in northern NSW, 9 in coastal southeast Queensland, 5 in the Darling Downs/South Burnett, 1 in Central Queensland and 1 in North Queensland.

The water use efficiency techniques developed on the Mutdapilly farmlets were tested on two companion farms in southeast Queensland – using an EnviroSCAN to schedule the same volumes of irrigation water normally used by the farmer, but applied strategically to match plant requirements. The farms increased ryegrass spring growth and utilisation – and delayed the warm season onset of water stress – by irrigating more in spring when plants were actively growing.

At the same time, adjustments were made to grazing management to increase ryegrass pasture utilisation by basing grazing on the 2 to 3 leaves per tiller stage, and by grazing down to the optimum measured height of 5 cm.

On one farm, these changes resulted in an improvement of 100% in water-use efficiency and 85% in pasture utilization.

M5 INFO SERIES

The water-use efficiency aspects of the *Sustainable dairy farm systems for profit* project will provide farmers in the region with information on the water use efficiency of common forages, and how to make optimum use of rainfall plus available irrigation.

A series of information sheets about using water efficiently will be published as part of the M5 Info Series. Topics will include a summary of findings from the *Sustainable dairy farm systems for profit* project; the water use efficiency of commonly used forages; the water use efficiency of different farming systems; how to manage the farm for most efficient use of water; and planning forage according to water. This information sheet is just the beginning.

These topics in the M5 Info Series are available at www.dairyinfo.biz, on the home page look under,

- Information Databases
  - Dairy Farming - information handbook
    - Industry projects
      - M5 Farming Systems
        - M5 Info Series (New).

CONTACTS

Mark Callow Ph (07) 5464 8714
Email: mark.callow@dpi.qld.gov.au
Water use efficiency and forage production

Sarah Kenman Ph (07) 5464 8741
Email: sarah.kenman@dpi.qld.gov.au
Water use efficiency, environmental concerns

The *Sustainable dairy farm systems for profit* project at Mutdapilly Research Station and on associated commercial farms investigated the potential impact of intensification of five subtropical dairy farming systems on business productivity, on the social well being of farming families and on the farm environment.