Water use efficiency of forages on subtropical dairy farms

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

IN an era of highly variable, lower than average rainfall and limited irrigation water supplies, dairy farms in Australia's subtropical dairy region may feel sceptical about the potential to improve forage and milk production. However, improved water use could be the way forward.

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

The project has determined the total water requirements for a range of forages used on dairy farms, and the efficiency with which they use water to produce forage and milk. The water use efficiency of forage production from irrigated grazed temperates ranged from 1.0 to 1.8 tonnes dry matter per megalitre of water (DM/ML). Irrigated tropical forage had a higher forage water use efficiency – 3.7 tonnes DM/ML for maize and 3.6 tonnes DM/ML for forage sorghum.

Without supplementary irrigation, dry matter production and water use efficiency was much lower for all forages. A double-cropped combination of annual ryegrass and forage sorghum produced the highest annual yield per ha – 28.8 tonnes DM/ha. A double-cropped area of conserved barley and maize recorded the highest forage water use efficiency over an entire year with 3.7 tonnes DM/ML of water.

INDUSTRY BACKGROUND

USING water efficiently is vital to the viability of dairy farms in northern Australia, to maximise the production of homegrown forage from minimal water input.

Many farmers in the subtropics rely on supplementary irrigation because of the inherently unreliability of summer rainfall and the characteristically low rainfall during the cool season. In recent years it has become increasingly difficult for farmers to source reliable irrigation water supplies due to drought and depleted water storages.

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.

Queensland Government
Department of Primary Industries and Fisheries

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 1* and *Table 2*.

TABLE 1. 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 2. 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 – 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.

With limited water available, this information would enable farmers to decide ahead which species were most likely to produce more dry matter and more milk from the water available.

The project also compared the water-use efficiency of the different farming systems.

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

Water-use (rainfall + irrigation) plot studies were undertaken for a range of tropical and temperate pastures and crops, and the water use of the five farming systems was documented and analysed over four years. Water use studies were also undertaken on companion farms.

Water-use considerations were incorporated in species selection, irrigation scheduling, grazing practice and fertilizer management on the farmlets – and in minimising surface runoff and nutrient loss.

Individual studies undertaken included

- Preliminary evaluation of the water-use efficiency of 10 forage species in subtropical southeast Queensland (2001-2002 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 recommendations 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.

Water use efficiency

Water use efficiency is the value of production, be it milk yield, pasture yield, crop yield or financial return 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.

TABLE 3. FORAGE dry matter production (t/ha), total water applied (ML) and water use efficiencies (WUE) (t DM/ML) averaged for years 1 (2002-03), 2 (2003-04) and 3 (2004-05). Not all forages include 3 years data.

Forage type	Yield (t DM/ha)	Effective rainfall (ML)	Irrigation (ML)	Total water requirements (ML)	WUE (t DM/ML)
Temperate					
Annual Ryegrass (I)	9.2	1.8	3.4	5.3	1.8
Perennial mixture (I)	9.9	4.5	4.3	8.8	1.1
Lucerne (I)	13.0	5.8	5.1	10.9	1.2
Barley (I)	8.4	1.0	1.2	2.2	3.8
Oats (R)	4.0	2.4	-	2.4	1.9
Tropical					
Forage Sorghum (I)	16.6	2.9	1.7	4.6	3.6
Maize (I)	19.8	2.8	2.5	5.4	3.7
Forage Sorghum (R)	13.0	4.2	-	4.2	3.0
Lablab (R)	8.6	3.8	-	3.8	2.4
Double-crop combination					
Ryegrass/sorghum (I)	25.8	4.7	5.1	9.8	2.6
Barley/maize (I)	28.1	3.9	3.7	7.6	3.7

I = irrigated R = raingrown

Total water requirements for individual forages

Individual forage water requirements for a range of forages used on dairy farms were determined. The water requirements were calculated from measurements made in field plots at Mutdapilly (*Table 3*), in large-scale grazed and conserved paddocks at Mutdapilly, and from monitoring on several commercial farms in southeast Queensland.

To estimate the amount of irrigation that a forage will need, subtract the likely average rainfall for the forage growth period from its total water requirement. Allow for the best and worst scenarios.

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 plot and farmlet studies showed that a double-crop of short-rotation annual ryegrass, followed by a summer forage crop of either sorghum or maize produced the highest DM yield/ha comparatively the most water efficient.

To test this on a commercial scale, herbage production and water use efficiency of a double crop were measured on two of the project's 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.

The water-use efficiency results from the two farms ranged from 1.6 to 2 tonnes DM/ML for annual ryegrass, and 3.2 to 3.4 tonnes DM/ML for maize. This was comparable with the more intensively managed M5 feed lot farmlet and small plot studies – suggesting that small changes to current practices will significantly improve water use efficiency, dry matter yield, forage utilisation and milk production from homegrown forages.

KEY FINDINGS

1. THE BENCHMARK milk production from homegrown forage is 1,100 litres of milk per megalitre of water for raingrown farms and 1,400 litres/ML for irrigated farms.

2. THE MOST WATER-USE efficient crops for dry matter yield are the summer, single-cut crops such as forage sorghum and maize for silage, compared with grazed forages.

A single-harvest crop avoids the recovery phase associated with grazing or cutting – when nutrient and water uptake slow or stop, and growth rate declines as stored energy is used to initiate regrowth.

The highest water-use efficiencies were maize grown for the M5 farmlet yielding 3.7 t DM/ML, conserved forage sorghum 3.6 t DM/ML, and conserved forage barley 3.8 t DM/ML.

3. STRIKE A BALANCE between water-use efficiency and maximum milk production

The physical attributes of summer forages make them more aggressive in extracting water, and allow them to produce up to twice as much forage per ML of water than temperate forages, but these same attributes also make them produce lower-quality forage than temperates. So temperates produce more milk per kg of dry matter grown, but yield less dry matter per megalitre of water (rain or irrigation).

Dairy farmers will need to strike a balance between optimum water-use efficiency and milk production from forage. Exclusively selecting for high water-use efficiency will not necessarily lead to maximum milk production.

4. FULLY EXPLOIT the region’s climatic pattern - summer-dominant rainfall and continued high radiation levels in winter – to grow forage all year round, aiming for 30 tonnes DM/ha.

The project showed that a double crop of short rotation annual ryegrass or barley, followed by a summer forage crop of forage sorghum or maize produced maximum DM yield of 29 tonnes of DM/ha with a WUE of 3.7 tonnes/ML.

5. BE FLEXIBLE and adjust to suit the season and available water (irrigation and likely rainfall).

Water restrictions continued through the life of the project, providing insufficient water to irrigate all planned forages. In light of water restrictions, choices need to be made.

For example, faced with reduced water irrigation water at the beginning of the 2005 autumn/winter season the decision was made on the M4 farmlet paddocks (which were to be planted to perennial temperate pasture mixes) to plant barley for silage instead – and to give it only one establishment watering, then rely on rainfall for the rest of the season.

The farmlet team could not justify planting a lucerne/clover/perennial ryegrass mix, and draw limited irrigation water away from more water-use-efficient faster gazing annual ryegrass during the cool season, and forage sorghum during the warm season.

If water is likely to be limiting through summer, the lesson from the farmlets has been to reduce the total area planted to maize to match water availability, allocating the crop a minimum of 6 ML per ha (rainfall + irrigation), and to plant more drought tolerant forage sorghum for conservation or grazing.

During very difficult dry seasons, the farmlets project demonstrated that growing and conserving forage sorghum is an efficient way to use limited water supplies and an important means of providing much-needed forage to fill feed gaps.

6. MANAGEMENT that increases the production and utilisation of high quality forage will also contribute to higher water use efficiency.

Water-use efficiency is not just about irrigation, or how efficient you are at using water. It is about increasing forage production and milk production from forage.

Water-use efficiency for milk production is simply the litres of milk produced from homegrown forage per megalitre of water used (rainfall + irrigation). It's another way to measure how well you are managing your feedbase, and how well you are converting forage to milk. It involves everything including species choice, seedbed preparation, planting and establishment, fertiliser use, irrigation use, making best use of rainfall, grazing management, and conserving any excess forage.

It also involves developing the most suitable herd structure – including breed and calving pattern – plus concentrate feeding to balance cows' forage-based diets.

Farms producing more than 1,000 L of milk per ML of water tend to follow best management practice, have higher stocking rates, and use some irrigation.

The project showed that forage yield and water-use efficiency were positively correlated Tightening up grazing management can impact dramatically on pasture utilisation. Southeast Queensland companion farms increased ryegrass pasture utilisation by up to 80% by basing grazing on the 2 to 3 leaves per tiller stage, and by grazing down to the optimum measured height of 5 cm. The same 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.

CONTACTS

Mutdapilly Research Station

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.