Dairy farming in the subtropics with raingrown pastures and limited irrigation - the M2 farmlet

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

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OVERVIEW

BASED on information collected from the M2 limited-irrigation farmlet at Mutdapilly, and scaled up on modelled date, the raingrown/limited-irrigation pasture system produced a positive cash flow and an average operational return on assets of 2.9% over four years. Average annual gross margin/cow was $747, and operating profit $158 per cow.

Between September 2001 and August 2005 - a period of below average rainfall and restricted access to irrigation - the Mutdapilly M2 limited-irrigation farmlet herd produced 6,530 litres/cow/year at 4.03% milk fat and 3.14% protein. Total milk production from the farmlet was 17,850 litres/ha/year, with an estimated 51% of production coming from homegrown forage.

INDUSTRY BACKGROUND

DAIRYING based on a forage system of tropical grasses, with a small component of irrigated annual temperate species for winter, is a common farming style in the coastal and upland areas of Australia's subtropics - practised by more than 30% of farms in Queensland and northern NSW.

These farms tend to be in areas receiving summer-dominant rainfall of more than 1,000 mm/year, and depend on irrigation to grow a relatively small area of annual winter ryegrass. Tropical pastures tend to commence growth in spring and are dormant or frosted in winter.

The *'Sustainable dairy farm systems for profit'* project tested this type of farming system with two periods of seasonal calving (spring and autumn) to coincide peak yield with peak pasture growth and quality.

Strengths and weaknesses of this dairy farming system in northern Australia

Strengths

- Irrigation provides some buffer against seasonal conditions.
- A small component of high quality temperate pasture can lift total milk yield from the farm and production per cow.
- Lends itself to two batches of seasonal calving, which can simplify herd management through the year.
- Strongly appreciating land values due to urbanisation and close proximity to major cities.
- Some of the most picturesque, liveable country in northern Australia, adding to farming lifestyle, aesthetics and proximity to facilities.

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Strengths (continued)

- Access to off-farm employment and to casual farm labour.
- Access to potentially low-priced by-products such as brewer's grain, fruit and vegetable pulps if close to a large urban centre.
- A common farming style, so there is the critical mass to develop and improve the technology of this farming system.

Weaknesses

- Proximity to urbanisation makes expansion difficult and places farming practices under close scrutiny.
- Competition for land and high land values.
- Forage production vulnerable to low rainfall and low water supplies.
- Irrigation increases the complexity of the farming system, increases workload, and capital investment.
- The system is vulnerable to irrigation water supplies becoming more expensive and more unreliable.
- Mating during hot summer months and significant reproductive difficulties make it difficult to retain a tight, spring-calving batch.
- Intensification (increased stocking rate, higher supplementary feeding) increases risk of pollution via runoff, leaching, odour.
- Storage and feedout facilities required for purchased forages.

LESSONS FROM THE M5 FARMING SYSTEMS PROJECT

The aim of the *Sustainable dairy farm systems for profit* project was to research the possibilities of the common dairy farming systems in the subtropical region. The project looked at intensification and its implications, with a goal of 10% return on assets and 600,000 litres per labour unit.

The project's M5 farmlets at the Mutdapilly Research Station provided four years of data, through both good and bad farming seasons.

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.

MUTDAPILLY M2 FARMLET HERD

THE 20-cow M2 farmlet herd was modelled on:

- Farm area of 130 ha with 360 cows (milking and dry).
- Small area of irrigation - 20% of the farm.
- A forage system based on grazed raingrown tropical pastures, with a small area of irrigated annual winter forage such as annual ryegrass.
- High stocking rate: 3.4 cows/ha on summer raingrown pastures; 13.5 cows/ha on winter irrigation area; 2.7 cows/ha on whole farm milking cow area.
- Two calving seasons – 50% in spring, 50% in autumn.
- High level of purchased supplementary feed – 3 tonnes grain/cow and 1 tonne hay/cow per year.
- High milk production – 6,560 litres/cow/305-day lactation; 670,000 litres/labour unit.
- $563,950 investment in plant and equipment.

Weather Conditions

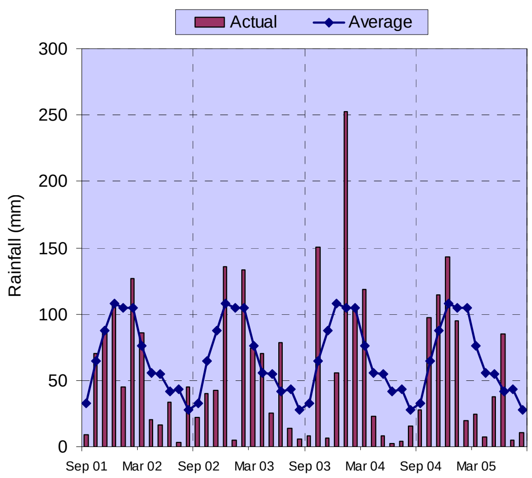
THE farmlet project years from 2001 to 2005 were based on the 12-months from September to August to fit with summer-winter seasons.

Rainfall

Mutdapilly average annual rainfall is 801 mm however average rainfall over the project was significantly less at 680 mm/year *(Figure 1).*

- 2001-02, 651 mm, 81% of average, reasonable spring, dry cold winter.
- 2002-03, 648 mm, 81% of average, dry summer but good winter.
- 2003-04, 751 mm, 94% of average, with a poor distribution, good start to spring and end to autumn, then dry summer and winter.
- 2004-05, 667 mm, 83% of average, good spring, poor autumn and early winter.

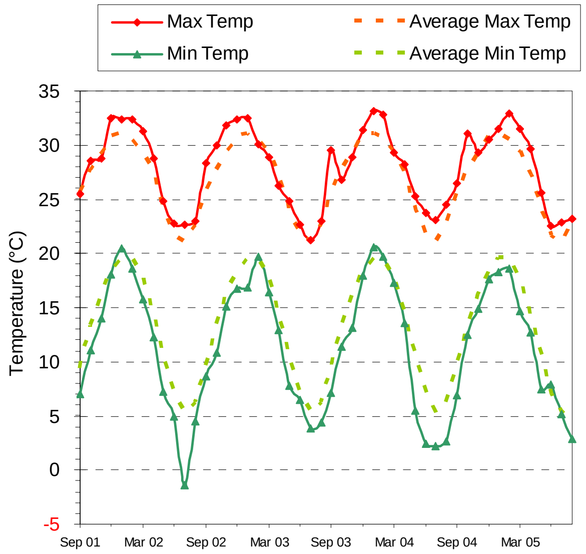
FIGURE 1. RAINFALL over the 4 years of the farmlets project.



Temperature

MUTDAPILLY is a location with wide temperature extremes *(Figure 2)*. The winter of 2002 was colder than average and the summer of 2003/04 particularly hot.

FIGURE 2. MINIMUM and maximum temperature at Mutdapilly over the 4 years of the farming system project.



Milk production

OVER the four-year project, average annual milk production from the M2 limited-irrigation farmlet was very close to its target of 6,560 litres/cow/year *(Table 1* and *Table 2)*. The M2 farmlet produced more than 6,200 litres/cow/year in its worst year.

TABLE 1. MILK production per cow from the M2 limited-irrigation pasture farmlet in each year of the project.

M2 farmlet	Litres/cow/year	Variation%
Budget/target	6,560	
2001-02	6,420	-2.1%
2002-03	6,570	+0.2%
2003-04	6,290	-4.1%
2004-05	6,870	+4.5%
4-year average	**6530**	**-0.4%**

The 4-year average milk production was 17,780 L/ha, with 8,270 litres/ha (46%) from homegrown grazed and conserved forage (by reverse calculation).

Average liveweight for the herd over the four years was 546 kg.

TABLE 2. AVERAGE milk yield, milk composition and liveweight of animals in the M2 farmlet over the 4 years of the project.

Litres/cow/year	6,530 litres
Litres/cow/day	21.2 litres
Milk fat	4.03% 258 kg
Protein	3.14% 201 kg
Lactose%	4.97%
Milk solids kg	459 kg
SCC (x 1,000)	258
Liveweight kg	546 kg

Figure 3 and *Figure 4* present daily herd and average litres/cow milk production patterns for the scaled up 360-cow M2 herd with its 50% spring and 50% autumn batch calving. These figures are based on the 20-cow farmlet herd

Maximum daily temperatures above 30ºC from December '03 to February '04 dramatically reduced milk production over this period – due to heat stress and its impact on dry matter intake, plus a lowering of forage quality, with irrigation difficult to manage during such heat.

FIGURE 3. DAILY herd milk production pattern (L) for a 360-cow, M2-style herd.

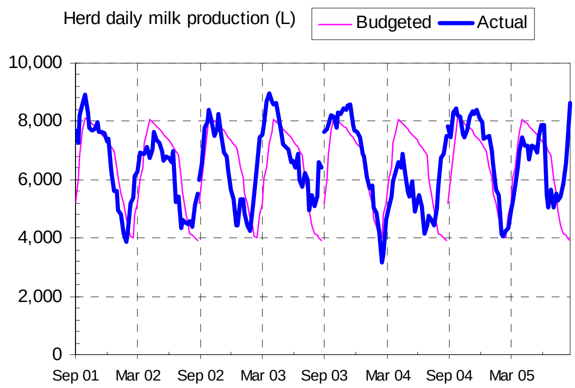
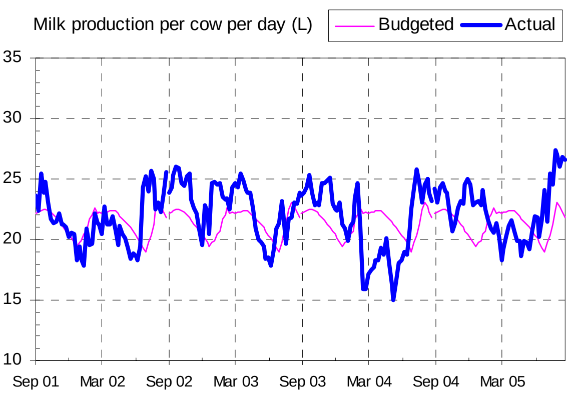


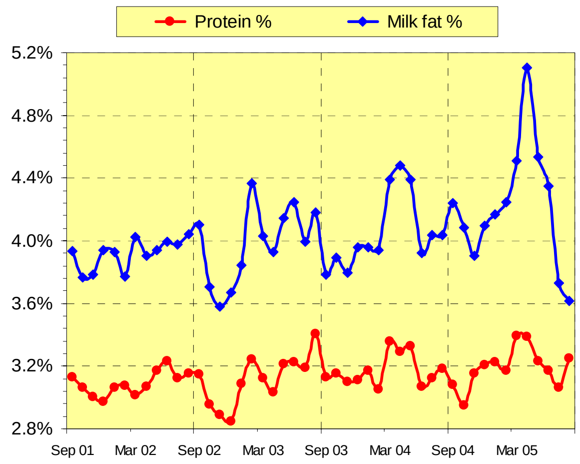
FIGURE 4. DAILY milk production pattern (L) per cow in a 360-cow, M2-style herd.



Milk composition

Figure 5 gives monthly milk composition for the M2 herd over the 4 years. Part of the variation can be explained by stage of lactation effects from autumn and spring batch calving, but there are also effects of nutrition and cow body condition.

FIGURE 5. MILK composition for the M2 farmlet herd over the four years.



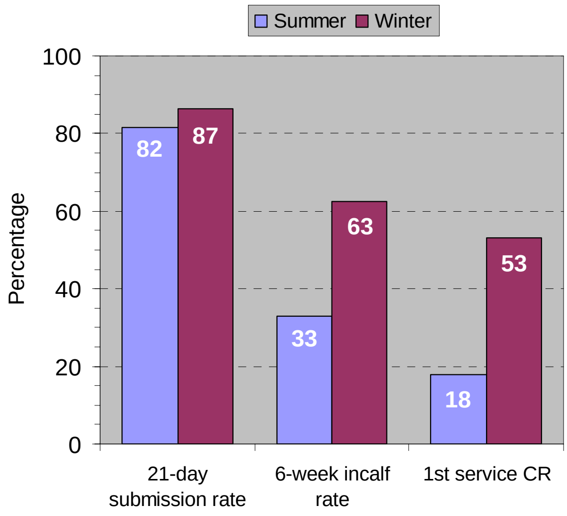
Calving pattern and reproduction

THE planned calving pattern for the M2 farmlet was 50% calving in spring and 50% calving in autumn, based on the annual predicted feed budget. The calving pattern was designed to maximise feed utilisation and to ensure that cows in early lactation had potential access to the largest volume of quality pastures.

The 12-week summer mating period was planned to run from 20th November to 12th February to provide a spring-calving period from 29th August to 21st November. The winter mating period was planned for 2nd May to 7th July for autumn calving from 8th February to 19th April.

On the M2 limited-irrigation farmlet, 21-day submission rates were reasonable (above 80%) for both summer and winter mating seasons, indicating that cows were cycling and detected in heat in both seasons *(Figure 6).*

FIGURE 6. M2 FARMLET herd summer and winter 21-day submission, 6-week in calf and 1st service conception rates (%).



However, the 6-week in calf rate shows an obvious seasonal effect, with 63% for winter mating but only 33% for summer mating, a reflection of conception rates. Winter first-service conception rate averaged just over 53% while summer first-service conception rate was only 18%.

Inseminator error was checked and discounted and a highly-interventionist approach to reproductive management adopted.

To satisfy the research methodology, cows that did not fall pregnant in the mating season corresponding to their calving season were replaced when 300 days in milk with a pregnant cow due to calve in the appropriate calving season.

In the economic analysis of the enterprise, an allowance was made for the cost of replacing animals. On a commercial farm, well-bred Holstein Friesian cows producing 7,000 litres/cow/year would milk on in late lactation, and with increasing fat and protein %, would continue to produce adequate milk solid yields. A 14 to 15-month inter-calving interval could be tolerated with these types of animals, but an extended batch calving or year-round calving pattern would be required.

Changes were made to the mating periods during the project - with summer mating starting a month earlier in an attempt to overcome summer reproduction problems.

Pastures and crops

THOUGH the simplest of the grazed farmlets, the forage plan for the M2 farmlet *(Table 3)* still needed to be flexible to adjust to changing rainfall and irrigation availability. In 2003-04, part of the irrigated annual ryegrass area was planted to oats instead, followed by an early sorghum crop to make best use of limited water.

Table 3. TABLE 3. PERCENT and area of forages on a 132 ha modelled M2-style farm.

% area	Ha	Forage type
80%	105	Tropical grass area
20%	27	Irrigated ryegrass double cropped with forage sorghum
100%	**132**	**Total farm milking area**

The farmlet stocking rate was 2.7 milking cows/ha. With batch calving, there were times of year when dry cows were agisted and the stocking rate on the milking cow area was lower.

This farming system is sensitive to rainfall distribution, which has a major impact on forage dry matter production. *Figure 7* presents rhodes grass growth rate over three summers. Summer rainfall in 2003/04 was favourable for production of rhodes grass and forage sorghum – resulting in a 100% increase in total forage DM yield compared with the previous year. Tropical rhodes grass quality was highest in November-December and lowest in April-May when pastures matured and senesced.

FIGURE 7. THE VARIABLE pattern of rhodes grass growth across the last 3 years of the project, highlighting the vulnerability of this system to seasonal conditions.

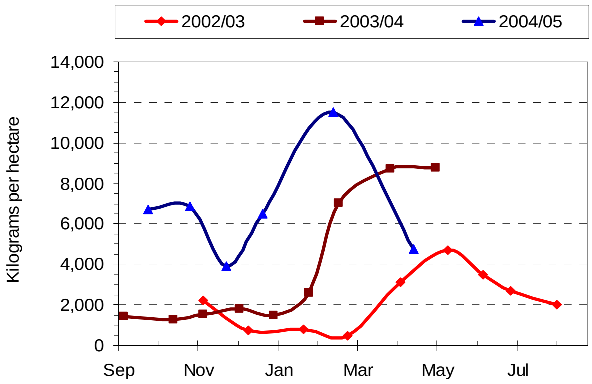
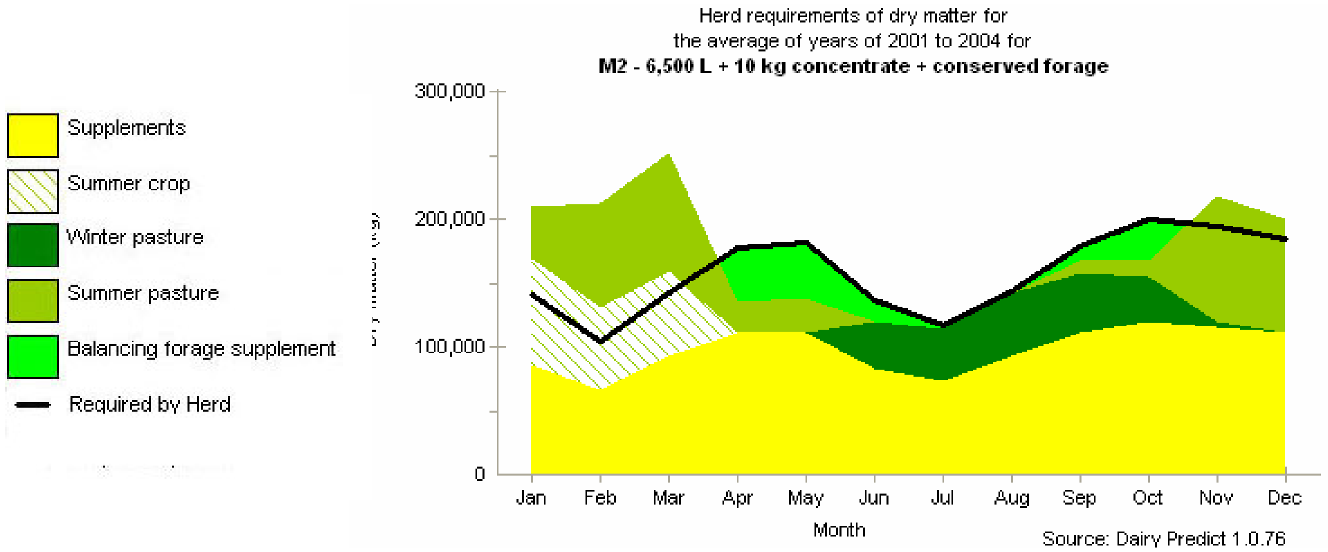


Figure 8 represents the M2 farmlet feed plan using the dairy feedbase decision model Dairy Predict. The feed plan shows a modest surplus of forage in summer, and a requirement for balancing forage supplement to fill shortages from early autumn to late spring.

The actual quantity of supplementary forage fed is presented in *Figure 9.*

FIGURE 8. A REPRESENTATION of the forage supply and supplements fed to the spring and summer batch calving M2 farming system produced by Dairy Predict.



Conserved forage - homegrown and purchased

THE M2 farmlet had a budget to purchase 1 tonne of hay cow/year. M2 fed more than its budget for purchased conserved forage, due to dry seasonal conditions.

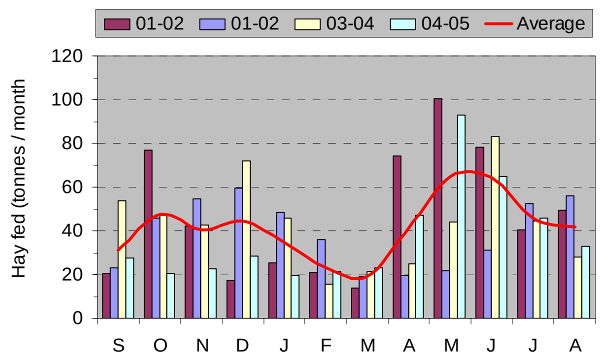
One of the priorities of each farming system was to conserve forage whenever possible. The only opportunities to conserve forage on the M2 farmlet were during summer. 92% of homegrown conserved forage came from forage sorghum grown on the irrigation area, which was conserved as wrapped round bales of haylage. A small amount of rhodes grass hay was also made in the last two summers of the project *(Table 4).*

TABLE 4. QUANTITY of conserved forage fed on the M2 farmlet each year and percentage that was homegrown

	2001-02	2002-03	2003-04	2004-05
Tonnes hay/cow	1.6	1.3	1.5	1.2
% homegrown	19%	25%	46%	32%

The pattern of feeding conserved forage is shown in *Figure 9*. As the farmlet herd was fed a partial mixed (PMR) some forage was fed throughout the year. The quantity of hay fed averaged 500 tonnes/year, ranging from 450 to 560 tonnes/ year. Expressed as silage equivalents the average was 1,200 tonnes/year.

FIGURE 9. THE AMOUNT of conserved forage fed to the M2, 360-cow enterprise each month in each year of the project, plus the average over the 4 years.



Fertiliser use

TABLE 5 presents the quantities of nitrogen fertiliser applied to forage areas on the M2 farmlet. Low rainfall was the main reason for lower N applications in some years. The rate of N use on tropical pastures (246 kg N/ha) would be towards the upper limit for an 800 mm rainfall environment. Use of 268 kg N/ha on the irrigated pasture/crop area would not be considered to be high.

Table 6 presents the amounts of N applied to the M2 farmlet per cow per year. By industry standards, the average N fertiliser use of 93 kg/cow/year on the M2 farmlet is regarded as low use of N fertiliser. However the quantity of N coming onto the farm through 3 tonnes of supplements/cow/year was high - 213 kg N/ha/year or 78 kg/cow/year - some of this N would have been redistributed to paddocks in dung and urine.

TABLE 5. NITROGEN fertiliser applications per hectare for each pasture and forage type on the M2 farmlet.

Forage type	Kg N/ha applied in year				Average Kg N/ha
	01/02	02/03	03/04	04/05	
Tropical grass	285	276	187	246	246
Irrigated ryegrass - sorghum	276	268	230	298	268

TABLE 6. NITROGEN fertiliser applied to the M2 farmlet per cow per year.

	Year				4-year average
	01/02	02/03	03/04	04/05	
Kg N per cow	104	101	73	94	93

Irrigation and water use

RAINFALL over the four years averaged 680 mm/year, compared with the Mutdapilly average of 801 mm *(Figure 1)*. One megalitre (ML) water is equivalent to 100 mm rainfall over 1 hectare.

The M2 limited irrigation farmlet was designed to have 20% of the farm irrigated - consistent with farms with a similar forage system. The irrigation allocation was 6.0 ML/ha or 0.45 ML/cow.

Irrigation records were available for three winter-summer seasons (April to March) from 2002 to 2005.

- In 2002-03 irrigation was relatively unrestricted, and the farmlet received 83% of its total allocation.
- In 2003-04 restricted irrigation water supply and pumping difficulties limited the total volume of irrigation water to 46% of allocation. Up to 40% of the annual ryegrass area was substituted with a more water-efficient oats crop, and the winter irrigated season for the oats crop was reduced.
- In 2004-05 irrigation use was back to normal, and M2 received 107% of its allocation.

Over the 3 years of data collection, the M2 farmlet received 79% of its irrigation allocation, equivalent to 4.73 ML/irrigable ha, 0.96 ML/farm ha or 0.35 ML/cow *(Table 7)*.

TABLE 7. IRRIGATION water allocation and use in the M2 farmlet.

Allocation		% allocation available		
Per ha	Per cow	02-03	03-04	04-05
6.0	0.45	83	46	107

Effective rainfall

In calculating water use efficiency (WUE) of forages and milk production, irrigation plus effective rainfall (rather than total rainfall) was used. Effective rainfall is the fraction of total rainfall that is available for pasture and crop growth. Daily rainfall of less than 5 mm was excluded, and only the first 50 mm of heavy rainfall included in daily totals. For crops, only 20% of total rainfall in the preceding fallow was considered effective.

Water use efficiency of forage production

Typical forage yields (tonnes DM/ha), and WUE (tonnes of DM/ML effective rainfall + irrigation) for irrigated ryegrass-forage sorghum and raingrown rhodes grass in the M5 project are given in *Table 8*.

TABLE 8. AVERAGE yields (t DM/ha) and WUE (t DM/ML) of forages in the M2 farmlet.

Species	Yield	Effective rainfall + irrigation	WUE
Ryegrass *	9.2	5.3	1.8
Forage sorghum *	16.6	4.6	3.6
Rhodes grass	6.7	4.0	1.6

* Irrigated double cropped

In *Table 8*, the M2 farmlet highlights the difference in water-use efficiency for forage production between tropical and temperate forage crops. While ryegrass plays an important role in filling the winter/spring forage gap with quality paddock feed, forage sorghum uses water very efficiently in summer to provide large yields of forage, which can be conserved to fill autumn and spring feed gaps. As an example of the high yield possible, an opportunity crop of irrigated forage sorghum grown on the M2 farmlet in summer 2004/05 yielded 22.5 t DM/ha from 4.9 ML water (2.8 ML effective rainfall + 2.1 ML irrigation), for a water use efficiency for forage production of 4.5 t DM/ML.

Water use efficiency of milk production

WUE can be expressed as litres of milk from homegrown forage/ML water (effective rainfall + irrigation). A litre of milk from homegrown forage is a calculated figure based on total milk production adjusted for supplements and forage fed.

Figures for each farmlet are presented in *Table 9*. From rainfall and limited irrigation, the M2 farmlet recorded water-use efficiency for milk production from homegrown forage of 1,310 litres/ML water.

TABLE 9. EFFECTIVE rainfall and irrigation inputs (ML/farm ha) and WUE (L milk/ML water) in the M5 farmlets.

Farmlet	Effective rainfall	Irrigation	WUE
M1	5.8	0	1,020
M2	5.8	1.0	1,310
M3	5.8	0.4	790
M4	5.8	3.6	1,260
M5 feedlot	5.8	4.0	1,820

Rainfall and irrigation are expressed as ML/ farm ha. The cut and carry M5 feedlot had the highest WUE measured as milk produced/ML (effective rain + irrigation) water. The M2 (limited irrigation) and M4 (full irrigation) grazed pasture farmlets produced similar amounts of milk/ML water under very dry seasonal conditions. The M2 limited-irrigation pasture farmlet recorded higher water-use efficiency for milk from homegrown forage than the M1 (raingrown) and M3 (limited irrigation crops) farmlets - indicating the value of supplementary irrigation, no matter how limited.

Concentrate feeding

THE M2 farmlet feed budget incorporated 3 tonnes of grain concentrate/cow/lactation (10 kg/cow/day) and 1 tonne of hay/cow/lactation.

The project aimed to study the impact of intensifying the common farming systems of the region – including increased levels of concentrate feeding to maximise forage utilisation and to support higher production per cow.

The project aimed to use concentrates to optimise milk production from forage and increase returns per ha. Increased use of energy-dense concentrates is one of the best ways to do this, within the limits of a forage/grain ratio of 60/40 to 50/50 – which is optimal for cows of high genetic merit.

With a run of dry seasons, the average (homegrown + purchased) forage/concentrate ratio fed to the M2 limited-irrigation farmlet herd over the 4 years was 51/49.

The concentrate ration *(Table 10)* consisted of mixed grains, sorghum, barley and wheat; cottonseed and soybean meals, molasses and whole cottonseed, with formulation adjusted seasonally on the basis of forage nutrient content and availability and the herd's level of production and stage of lactation. The herd also received trace minerals and phosphorus.

TABLE 10. AVERAGE concentrate ration fed to the M2 farmlet herd (kg/cow/day as fed).

M2 concentrate	Kg/cow/day (as fed)
Grain	5.3
Molasses	2.5
Protein meal	1.0
WCS	1.8
Minerals	0.3
Total	**10.8**

As well as feeding higher rates of concentrate, each farmlet used a higher stocking rate than the industry average. The focus was maximum production and utilisation of forage, including conservation of any surplus.

Method and timing of feeding concentrates to avoid slug feeding was an important management consideration with the higher rates of concentrate.

The grazed M2 cows were fed their concentrate rations as 4 kg of mixed grain/day in the dairy, with the balance of grain and protein meal, plus a small amount of forage, in a partial mixed ration once a day along a fence line in a concrete trough.

Managing the cost of purchased feeds – both concentrates and forages - is critical to the performance of this system. With concentrate prices increased by drought conditions during the project *(Table 11)* high grain feeding impacted on total variable costs. Purchased feed and forage costs were highest in year two (2002/03) at 18.3 c/L. However production was maintained and concentrate costs were spread over a large volume of milk.

TABLE 11. AVERAGE cost of the M2 concentrate mix, including molasses, over the 4 years of the project.

M2 concentrate cost	01-02	02-03	03-04	04-05
$ per tonne as fed	222	296	227	204

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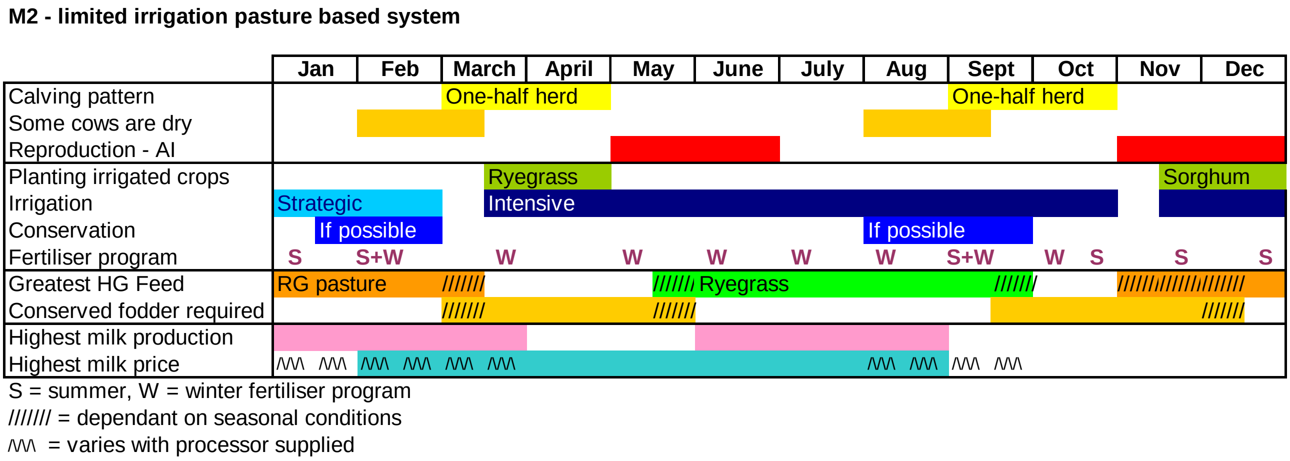
Calendar of operations and farm activities

A YEARLY calendar of operations and farming activities for the M2 farmlet is presented in *Figure 10.*

FIGURE 10. A CALENDAR of farming operations for the M2 farming system



Nutrient balance on the farmlet

SUPPLEMENTARY feeds supplied 45 to 80% of N inputs onto the farmlets, highlighting the economic and environmental importance of distributing manure over the farm.

All forage systems on the farmlets used less N fertiliser than anticipated. Dry weather reduced the opportunities to apply N to raingrown crops and pastures. Also, soil analyses showed increasing soil N levels, so planned application amounts were reduced. This indicates that fertiliser application rates on individual farms may need reconsidering.

A simple whole-farm nutrient-balance model was developed during the course of the project to consider the ratio between farm inputs (supplementary feeds, fertiliser) and outputs (milk, meat and forage sales) in terms of their nitrogen (N), phosphorus (P) and potassium (K) content.

Running figures for all farmlets through *The Farm Grid Nutrient Balance Model* produced the results summarised in *Table 12*.

N ratios are difficult to interpret; ratios of between 3.0 and 4.0 are about as efficient as could be expected with systems heavily reliant on N fertiliser. The N input/output ratio was outside this range on farmlets M1 and M2, suggesting potential for refinement of fertiliser rates.

Most interest is with P, with a ratio of 1.0 to 1.5 considered ideal, and anything above 2.0 seen as undesirable. All systems were within acceptable limits at the whole farm scale. K is not seen as a problem as a potential pollutant.

TABLE 12. THE units of nutrient input for N (nitrogen), P (phosphorus) and K (potassium) required to produce a unit output (2001-2005).

Farmlet	N	P	K	Description
M1	5.8	1.9	3.9	Raingrown tropical pasture some oats
M2	5.1	1.7	3.6	Limited irrigation pastures
M3	3.6	1.9	1.6	Limited irrigation forage crops and ryegrass
M4	3.1	1.4	1.3	High irrigation pastures and forage crops
M5 feedlot	2.5	1.3	1.2	Feedlot home-grown irrigated silage and hay

Other environmental considerations

PADDOCKS producing raingrown rhodes grass and irrigated annual forages (ryegrass-forage sorghum) on the M2 farmlet were routinely soil-sampled during the project to monitor soil pH, organic carbon, total nitrogen, bicarbonate-extractable P, nitrate-N, electrical conductivity and water content.

Monitoring showed significant residues of nitrate-N in the soil profile at the end of some growing seasons in raingrown rhodes grass paddocks fertilised with up to 285 kg N/ha/year *(Figure 11)*. This indicates that potential forage yield (and therefore fertilizer use) was overestimated. On the high-clay soils and low rainfall conditions at Mutdapilly, this did not present a problem for potential loss of N through leaching below the plant root zone. However it could be a risk in soils and weather conditions where deep drainage is likely.

A double-cropped irrigated ryegrass-forage sorghum paddock receiving 350 kg N/ha/year on the M2 farmlet showed significant residual nitrate-N levels at more than 60 cm soil depth at the start of the winter annual growing season. For shallow-rooted ryegrass, this N residue is at significant risk of being leached deeper into the soil with irrigation. Significant nitrate-N was also found at the end of the winter growing season. On the Mutdapilly farmlet, the herd was allowed to both forage and loaf on the ryegrass pasture – only being removed for milking.

Soil organic carbon levels, an indication of soil organic matter, had risen from 2 to 2.5% under double cropping with irrigation.

Visual estimates were also made of soil cover during summer and winter (*Figure 12)* of the irrigated and double cropped ryegrass-sorghum paddocks. Double-cropping provides good soil protection for most of summer.

Figure 11. The distribution of nitrate-N (mean sample values) in the soil profile at the end of the growing season for raingrown rhodes grass.

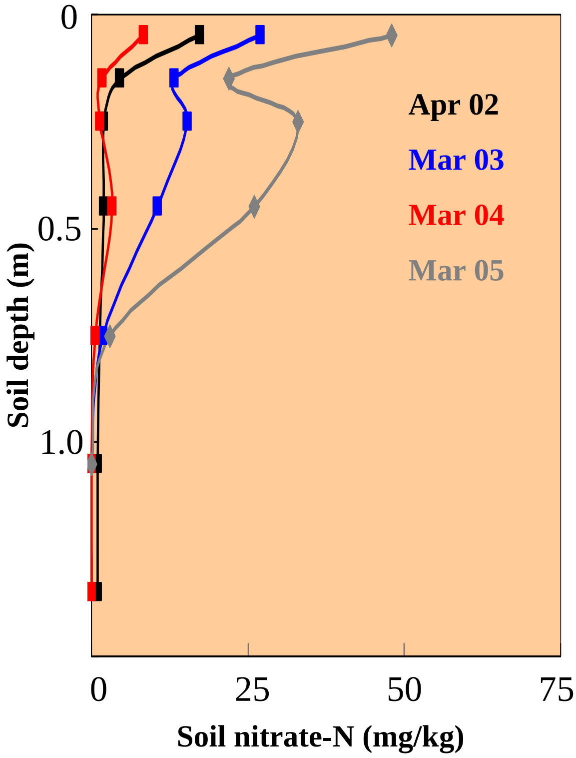
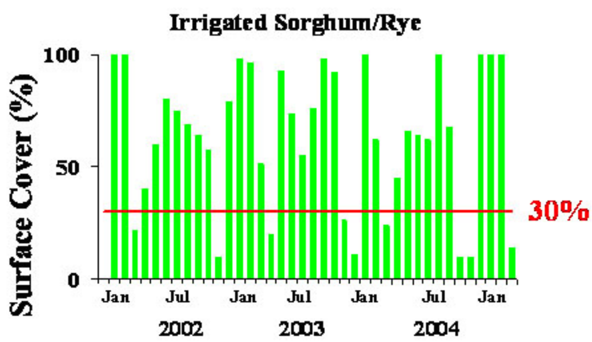


Figure 12. SOIL cover under an irrigated sorghum-ryegrass cropping program.



Business results

AN average milk price - based on the pricing formulae used by Dairy Farmers, Parmalat and Norco - was used in the financial and business trait analysis for all farmlets *(Table 13)*. The difference in milk receipts between farmlets reflects varying season of supply, milk composition and volume incentives.

Dairy income includes milk receipts, livestock sales, fuel rebates and genetic incentives.

Individual dairy farms will know their average dairy income, so can make a comparison between the farmlet data and their own enterprise.

TABLE 13. AVERAGE milk receipts and dairy income for each of the modelled farmlet herds.

	M1	M2	M3	M4	M5 feedlot
Milk receipts c/L	33.3	34.1	34.6	34.9	37.2
Dairy income c/L	36.6	37.4	37.9	38.4	40.9

The capital required to change a typical QDAS 125-cow M2 farm into a 360-cow enterprise is presented in *Table 14*.

The 4-year average key financial indicators for each of the Mutdapilly modelled farmlets are presented in *Table 15*. All farming systems, including M2, had a positive operational 4-year average return on assets.

Scaling up the production results and costs of the 20-cow Mutdapilly M2 farmlet herd over 4 years, the limited-irrigation pasture-based M2 farming system returned a gross margin of $747/cow/year, for an average operating profit of $158/cow/year.

Annual business results for M2 are summarised in *Table 16*. Because this system exceeded its purchased forage budget during the drought, it achieved very modest business results.

TABLE 14. ESTIMATED capital required in 2000-01 to change a typical 125-cow M2 farm (from QDAS) to a 360-cow herd on the same land area.

Extra capital required - M2	**$**
Land	0
Buildings	
Dairy buildings	50,000
Total Buildings	50,000
Plant/equipment	
Vat	70,000
Feed pad	9,500
Feed wagon	80,000
Water	12,000
Silos	15,000
Effluent	40,000
Total Plant / equipment	226,500
Livestock	287,450
PDA / Shares	0
TOTAL	**563,950**

TABLE 15. BUSINESS traits and KPIs of the five modelled farming systems, averaged over the 4 years of the project.

BUSINESS TRAIT SUMMARY	**M1**	**M2**	**M3**	**M4**	**M5**
Liquidity					
Dairy cash surplus ($)	20,757	63,146	149,852	192,817	518,213
Interest costs per cow ($)	155	155	159	162	150
Solvency					
Equity %	57%	60%	60%	65%	64%
Liabilities per cow ($)	2,216	2,217	2,267	2,312	2,141
Profitability					
Change in Net Worth per year ($)	56,995	30,281	46,372	40,510	89,483
Return on Assets % (operational)	0.7%	2.8%	6.3%	6.6%	13.9%
Return on Assets % (Capital+operational)	7.7%	7.0%	9.6%	11.1%	18.0%
Return on Equity %	-4.1%	-0.1%	5.8%	6.4%	17.7%
Operating profit ($/cow)	40	158	358	436	823
Efficiency					
a) Capital efficiency					
Asset turnover ratio %	44%	45%	46%	43%	64%
b) Financial efficiency					
Feed related costs (c/L)	17.8	17.9	15.8	15.9	16.8
Forage costs (c/L milk from forage)	7.5	7.6	7.0	9.6	10.4
Margin over feed related cost (c/L)	18.9	19.5	22.1	22.5	24.1
Gross Margin per cow ($)	640	747	950	1,128	1,497
c) Physical efficiency					
L / cow / year	6,148	6,534	6,871	7,395	9,182
L / hectare	11,491	17,779	9,304	20,541	39,492
Litres / labour unit	551,719	672,050	618,367	665,526	883,815
Cows / labour unit	90	103	90	90	96

TABLE 16. BUSINESS traits and KPIs of a typical M2 farm in QDAS in 2000-01, and the annual and 4-year average figures from the modelled M2 farmlet.

	QDAS	M2				
BUSINESS TRAIT SUMMARY	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**Average**
Liquidity						
Dairy cash surplus ($)	26,813	49,628	-31,744	54,916	179,785	63,146
Interest costs per cow ($)	131	155	155	155	155	155
Solvency						
Equity %	83%	59%	59%	60%	61%	60%
Liabilities per cow ($)	1,875	2,217	2,217	2,217	2,217	2,217
Profitability						
Change in Net Worth per year ($)		11,360	23,816	36,479	49,470	30,281
Return on Assets % (operational)	0.4%	1.8%	-2.1%	2.6%	8.9%	2.8%
Return on Assets % (Capital+operational)		5.5%	1.9%	6.9%	13.6%	7.0%
Return on Equity %	0.4%	-1.8%	-8.3%	-0.4%	10.1%	-0.1%
Operating profit ($/cow)	39	99	-112	142	501	158
Efficiency						
a) Capital efficiency						
Asset turnover ratio %	18%	44%	45%	43%	47%	45%
b) Financial efficiency						
Feed related costs (c/L)	14.9	17.6	21.8	17.5	15.0	17.9
Forage costs (c/L milk from forage)		7.8	7.5	8.1	7.1	7.6
Margin over feed related cost (c/L)	20.6	19.3	15.4	19.9	23.4	19.5
Gross Margin per cow ($)	806	710	484	724	1071	747
c) Physical efficiency						
L / cow / year	5,399	6,419	6,571	6,289	6,857	6,534
L / hectare	2,509	17,466	17,879	17,112	18,659	17,779
Litres / labour unit	337,444	660,214	675,836	646,833	705,319	672,050
Cows / labour unit	63	103	103	103	103	103

COMPANION FARMER EXPERIENCES

The M5 project assessed the real expansion opportunities and implications for subtropical dairy farms by involving 22 commercial farms as Companion Farms to the project. The 6 farms in northern NSW, 9 in coastal southeast Queensland, 5 on the Darling Downs/South Burnett, 1 in central Queensland and 1 in north Queensland represented a broad cross-section of Australia's subtropical dairy farms – in terms of location, herd size and farming style.

Adapting to dry seasons. Typical of many subtropical dairy farms relying on some irrigation, the M2-style companion farms have faced unreliable and declining water volumes.

Some limited-irrigation farms have decided to stop irrigating, due to the unreliability of water supplies and the costs associated with irrigating. One companion farmer with a 208 ML allocation ceased irrigation and purchased a second-hand mixer wagon as a more reliable feeding system for his herd.

Many are learning to opportunity crop with short, quick-growth raingrown crops such as oats, forage sorghum and lablab – for both grazing and conservation.

An easy system. Farmers generally commented that this is an easy lower-cost farming system in 'normal' seasons. It is relatively simple, does not require a lot of labour, there isn't as much tractor work as a cropping-based farm; it is not as labour-intensive as a feedlot; and there is less need for non-milking labour.

The opportunity sometimes arises to conserve quality winter feed and summer forage crops.

Improving pasture utilisation. Improving pasture utilisation – especially high quality irrigated temperate pastures – has led to higher milk production from these pastures, increased stocking rate, and excess quality forage being available for conservation.

Managing pastures well for higher stocking rate has allowed the farm to carry more stock and to lift total milk production from the farm.

Grazing management (grazing at the 3-leaf stage and down to 5 cm) has also improved ryegrass growth and use, and water-use efficiency.

Water use. There is increasing awareness amongst farmers of improving the efficiency of their use of limited water supplies – by attention to equipment maintenance and setup, better understanding of their pasture requirements for water, and better use of the pasture that they water and grow.

Several farms using this style of M2 system have moved from traveller and hand-shift irrigation equipment to solid set – to reduce labour, to water to pasture requirements (rather than equipment limitations) and to improve water distribution.

They are also paying greater attention to using any available water as efficiently as possible – watering ryegrass on the basis of both need and an understanding of the crop, rather than on set irrigation schedules.

Switching irrigation water in October/November from ryegrass to tropical forage crops such as forage sorghum results in better water-use efficiency and higher forage yield from the irrigated area. Summer forage crops will also mop up any residual nitrogen from the ryegrass season.

In farming systems that rely on conserving homegrown forage over summer, if there is likely to be less than 6 ML of water available then forage sorghum will give a more reliable yield than maize.

Calving pattern. Batch-calving herds listed the advantages as concentrated calf rearing and AI over a short period; reducing labour requirements for the rest of the year; ability to take clear break every year; well-timed calving batches can maximize pasture utilization and lower production costs.

Herds that are batch calving raised a number of management issues: the need for adequate facilities including calf-rearing sheds, and milking shed/vat/machine capacity to handle a large number of fresh cows and new calves; the need for extra seasonal labour requirements at calving/early lactation/heat detection/mating; the need for skilled and well-managed labour at crucial periods to ensure a tight calving pattern, fresh cow care and calf rearing; fluctuating milk volumes and therefore cash flow; the need to adhere to strict mating period; and the need to decide the fate of cows that are not in calf during that period.

Feeding out supplementary feed. Grain supplements are generally fed in the dairy. Some farmers already feeding 1.8-2.0 tonnes grain/cow/year believed they could increase that to 3 tonnes/cow/year (equivalent to 10 kg/cow/day) and still feed all grain in the dairy, provided it was in pellet form. Other farms believed that the limit of grain feeding in the bails was 6 kg/cow/day.

Feedout facilities tend to be minimal on many pasture-based farms, with hay and silage fed along fence lines in dry weather and on feed pads (where available) in wet conditions. Some farms have already invested in mixer wagons, hay rings and improved feedout facilities. However further intensification - with associated increased supplementary feeding – is likely to require extra investment in facilities and equipment on the majority of farms.

Mixer wagon or not? Companion farmers shared a variety of opinions on the place of a mixer wagon in a raingrown/limited-irrigation pasture-based farm.

Arguments for a mixer wagon included reduced feed wastage; a consistent reliable diet for milking cows; the ability to incorporate daily feeding of purchased or homegrown conserved fodder + the extra grain in an intensified pasture system. There appeared to be preference for a mixer wagon vs. hoping for irrigation water.

Arguments against included cost (although second-hand wagon appeared a reasonable alternative to these farmers), the need for a permanent feed pad or feeding shed, and extra labour requirements.

CONCLUSIONS AND RECOMMENDATIONS

Business considerations. There appears to be potential for increased production per cow for limited-irrigation pasture-based farms in the subtropical dairy region. 2005 QDAS data indicates average production per cow in northern NSW is 5,250 litres/cow and in SEQld it is 5,390 litres/cow. The Mutdapilly M2 limited-irrigation pasture farmlet averaged 6,530 litres/cow/year over four years, under less-than-ideal dry conditions and irrigation water restrictions.

It is important to match the farming system to available resources (the natural resource base, the financial base and the social/management base) rather than the other way around.

The farmlet study found that the three key drivers of profit in dairy enterprises were production per cow, number of completed lactations and proportion of homegrown vs. purchased feed.

With increased competition for reducing supplies of irrigation water, many ‘irrigation’ farms have to operate as raingrown dairy farms - so the management options raised by the raingrown M1 farmlet are also pertinent to M2-style farms.

Intensification. High stocking rates can accentuate the feed gaps that occur between forage seasons. Higher levels of supplementary grain and forage overcome this difficulty to some extent. However, higher stocking rates make it imperative to have as smooth and short a transition between summer/winter and winter/summer forage programs as possible.

The farmlets highlighted the greater risk of intensive farming systems. Difficulties experienced due to dry or wet weather, machinery and equipment breakdowns, irrigation water shortfalls – inevitable in all farming enterprises – have more impact in a more intensive system.

Intensifying a pasture-based system makes it more highly sensitive to drought, so the farm business needs to have planned alternatives – including the costs and returns of reducing herd size or reducing the amount of purchased feed. While a long-term drought requires more drastic management changes, a short-term feed shortage is best handled by maintaining feeding levels.

Impact of heat. Heat stress has a major impact on all dairy herds in the subtropical dairy region. It affected all farmlet herds at Mutdapilly, mainly through lower dry matter intake, lower milk production and poor reproductive performance during hot periods.

The major impact on the M2 herd was very poor reproductive performance in 50% of the herd that was spring-calved and mated from November onwards. Milk production was dramatically reduced between December 03 and Feb 04 – when maximum temperatures remained above 30 degrees C.

Calving pattern. Choose a calving pattern that is the best fit for both feed resources and seasonal milk prices through the year. The 50% spring-calving batch of cows in the M2 farmlet – cows dry July/August, calving from September onwards and re-mating from November onwards – was designed to match milk production to the spring flush of quality tropical pastures. However, in the Mutdapilly environment, poor reproductive performance meant this pattern was difficult to sustain.

Once you have a set calving pattern to make best use of the feedbase, it is important to maintain that pattern. The barriers to spring calving have been mentioned. Options to consider include changing to breeds and crossbreeds that may improve heat tolerance and reproductive performance.

Tropical forage. Make the most of regional advantages. Tropical pastures and crops have double the water-use efficiency for forage production compared with temperate species. They will generally produce twice as much forage per megalitre of rainfall. Take full advantage of that - including growing and conserving forage during peak periods of growth, for feeding out during low rainfall periods.

Well-grown and managed tropical grasses should be an integral part of all dairy forage systems in the subtropics. They can achieve high annual dry matter yield, maintain ground cover through summer, and build up soil organic matter. For example, the M2 raingrown Callide rhodes grass yielded up to 9 tonnes DM/ha over the 2003-04 summer.

Raingrown tropical forage crops such as forage sorghum and maize will produce more utilisable tonnes of dry matter per megalitre of rainfall than grazed tropical pastures, so they provide an opportunity for boosting annual dry matter yield on raingrown farms. They also provide a potential opportunity to produce silage during summer for feeding out the next year.

The key to maximising milk production from tropical pastures is the same as for temperate pastures - good growing practices including strategic use of fertiliser for maximum dry matter yield and quality, and grazing for maximum intake and quality. Maturing tropical grasses have higher fibre content than maturing temperate pastures - as high as 60-70% NDF. High diet NDF can restrict cow intake and lower milk production potential. For high producing cows the target for dietary NDF is 35%.

Tropical pasture forage can achieve milk production of 11.5 to 13.5 litres/cow/day. This is lower than the potential milk yields from temperates (15 to 17 litres/cow/day), but tropical species are well suited to the subtropical environment, and are the cheapest source of feed for milk production.

The feed base needs to be flexible, always open to alternatives, and able to adjust to changes in prices, forage availability and rainfall.

Conserving fodder. Periods of surplus growth need to be exploited by conserving excess forage. All farmlets – including M2 – had periods of the year when forage did not meet herd requirements. On M2 these anticipated gaps were filled with planned use of purchased forage. Despite the higher stocking rate than usual for a raingrown pasture/limited irrigation farm, there were also periods on the M2 farmlet when there was surplus rhodes grass and forage sorghum, which were conserved.

Water use. From the 4 years' study, the farmlets project developed several key water-use messages:

Each farm needs to find a balance between maximising milk yield and water-use efficiency for forage production. Water use efficiency for milk production is increased by including tropical forages, however their lower quality can limit total milk yield.

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

Single-cut forage has a higher water-use efficiency than grazed forage.

Water use efficiency is improved as forage yield and utilisation increases.

Losses in soil stored water during fallow need to be minimised.

Farming systems that have limited irrigation and heavy reliance on raingrown forage need to fully exploit the subtropics' climatic strengths, which include summer-dominant rainfall and high radiation levels in winter. Aim for 30 tonnes DM/ha/year. A double-cropped paddock of ryegrass and forage sorghum on the M2 farmlet yielded 22 tonnes/ha in one year (2003-04).

Purchased concentrates and forages. High levels of grain feeding can be profitable when combined with high production per cow, good forage utilisation and high stocking rate to prevent substitution of grain for forage. High utilisation of homegrown forage, including a combination of good grazing techniques and conserving surpluses, needs to be the focus.

Feeding grain supplements has direct benefits to milk production and the supply of starch can improve milk protein. Cow reproduction and condition also benefit.

The financial return from this farming system is very sensitive to changes in input prices. Planning and managing the supply and cost of purchased forage, grain and fertiliser is critical to the profitability and performance of this farming system. Having purchasing requirements and plans, plus adequate storage facilities in place, will enable forward and contract purchasing at lower prices. The alternative is to reduce reliance on purchased fodder by increasing available area – through purchasing or leasing extra land, or relocating the business to a forage-producing area with lower land price.

Environmental considerations. In a summer-rainfall environment, the M2 style farming system – with a high proportion of the farm devoted to summer-active perennial tropical grasses - protects the soil resource and minimises the risk of deep drainage. Access to irrigation water means a summer forage crop can often be grown on winter-forage land, providing soil cover and reducing the risk of erosion.

Intensifying the system with higher stocking rate and higher level of supplementary feeding has the potential to increase point-source pollution. Some investment may be needed in adequate feedout and effluent management facilities.

Fertiliser needs to be adjusted to take into account the level of nutrients brought onto the farm in purchased feeds.

M5 INFO SERIES

THE M5 Info series will provide dairy farmers and the industry with a wide range of information from the *Sustainable dairy farm systems for profit* project. Other topics in the series are available at www.dairyinfo.biz on the home page look under,

- Information Databases
  - Dairy Farming - information handbook
    - Industry projects
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Whole farm management and modelling

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.

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