Dairy farming in the subtropics with high use of irrigation on crops and pastures - the M4 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

Mark CALLOW, Rob CHATAWAY, Graeme BUSBY, Ross WALKER, Jeff ANDREWS and Ross ITZSTEIN

edited by **Anne CHAMBERLAIN**

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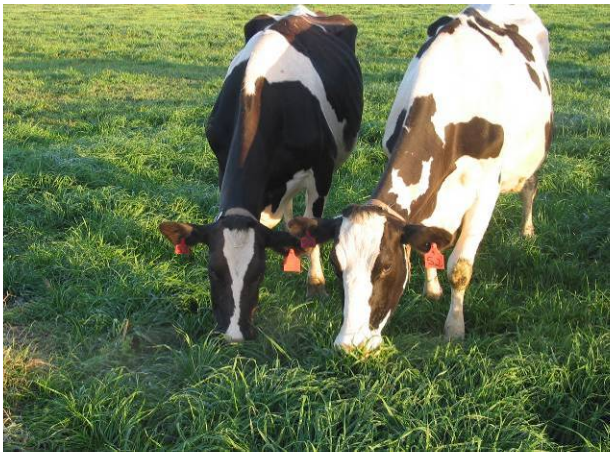
OVERVIEW

BASED on information collected from the M4 high-irrigation 20-cow farmlet at Mutdapilly, scaled and modelled to a 360-cow farm, the high-irrigation pasture system produced a positive cash flow and an average operational return on assets of 6.6% over the four years. Average annual gross margin/cow was $1,128 and operating profit $436/cow.

Between September 2001 and August 2005 - a period of below average rainfall and restricted access to irrigation - the Mutdapilly M4 high-irrigation farmlet herd produced 7,400 litres/cow/year at 3.90% milk fat and 3.18% protein. Total milk production from the farmlet was 20,540 litres/ha/year, with an estimated 55% of production coming from homegrown forage.



INDUSTRY BACKGROUND

DAIRY farming that depends on a high level of grazed, irrigated forage has been a traditional feature of Australia's subtropical dairy industry in the 800-1,000 mm rainfall zone, wherever there is arable land and access to reliable and sustainable water supplies. However, the number of subtropical dairy farms that are based on a high level of irrigation has reduced drastically in recent years - due to dry weather and irrigation restrictions (in turn due to low water supplies, increasing competition for water, and increasing water costs), and increasing competition for arable land in well-watered areas.

The pressure to increase production to remain viable has also forced many irrigation-based dairy farms to become more reliant on silage-based rations and more purchased feed inputs.

Characteristics of a high-irrigation M4-style subtropical dairy farm include access to reliable, sustainable water supplies; a forage base of irrigated annual and perennial temperate pastures, with some summer forage crops; generally year-round calving and milk production, but some batch calving to coincide with autumn/winter milk price incentives; higher than average milk production; higher than average stocking rate and high rates of N fertiliser.

Strengths and weaknesses of this dairy farming system in northern Australia

Strengths

- Irrigation buffers against rainfall deficiencies.
- Cows remain in good body condition with good reproductive performance.
- High milk output per unit of land.

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Strengths (continued)

- Milk composition tends to be stable and high.
- High diet quality and forage intake.
- Frequently in prime agricultural regions and flood plains, with less pressure from urban development.
- Good ground cover for most of the year.
- Potential to diversify into other enterprises/commodities.
- High aesthetic appeal with green pastures year-round.

Weaknesses

- Very dependent on reliability of irrigation water to maintain forage production and a high stocking rate.
- Requires 'wet weather' areas to avoid damage to soil structure and animal health.
- Relies on perennial pastures to overcome the autumn forage gap, but these pastures have limited resilience to the extremes of the subtropical summer and are often not effective in this role.
- Competition for land and water from other agricultural industries.
- High stocking rate, high level of supplementary feeding, high fertiliser and high irrigation all increase the risk for point-source and diffuse pollution.
- Requires a high level of infrastructure.

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/labour unit.

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

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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 M4 FARMLET HERD

The 20-cow M4 farmlet herd was modelled on:

- Farm area of 130 ha with 360 cows (milking and dry).
- Total forage area irrigated - at least 85% of the farm.
- A forage system based on grazed irrigated temperate pastures.
- High stocking rate – 3.3 cows/ha on the irrigation area; 2.8 cows/ha on whole farm.
- Two calving seasons - 35% in spring, 65% in autumn.
- High level of purchased supplementary feed – 3 tonnes grain/cow per year.
- High milk production - 7,100 litres/cow/305-day lactation; 635,000 litres/labour unit.
- $472,000 investment in plant and equipment to intensify the system.

Weather conditions

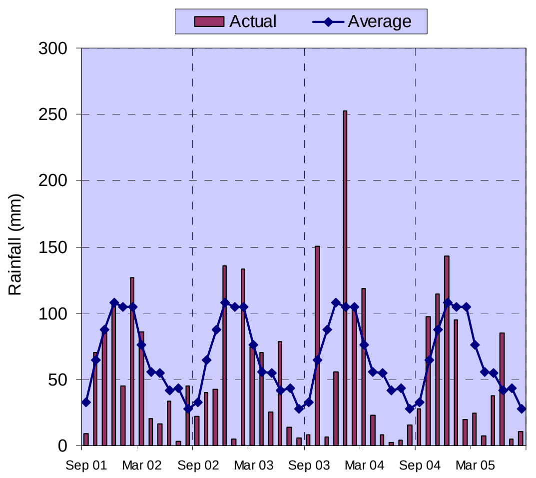
THE farmlet project years from 2001 to 2005 were based on the 12-months from September to August to fit with summer-winter seasons.

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.

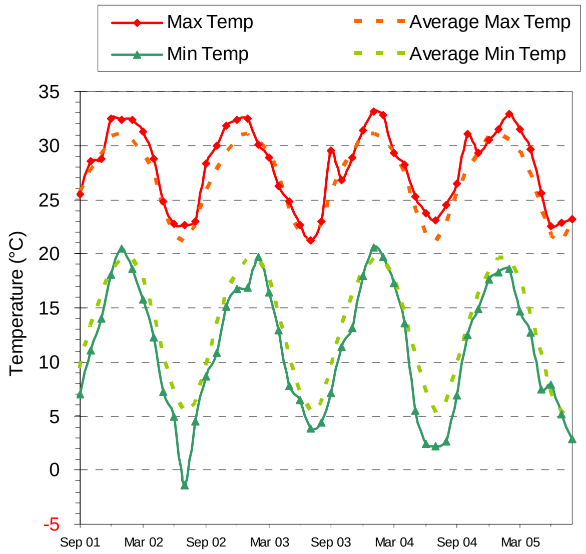
FIGURE 1. RAINFALL (mm) over the 4-years of the farmlets project.



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. MEAN monthly minimum and maximum temperature (ºC) at Mutdapilly over the 4 years of the farming system project.



Milk production

AVERAGE annual milk production was above the modelled target of 7,100 litres/cow/year in all years except the start-up year, *Table 1* and *Table 2.*

Average milk production per ha was 20,540 litres/ha with 11,350 litres/ha (55%) from homegrown forage.

TABLE 1. MILK production per cow from the M4 high-irrigation farmlet in each year of the project.

M4 farmlet	Litres/cow/year	Variation%
Budget/target	7,100	
2001-02	6,970	-1.8%
2002-03	7,950	+12.0%
2003-04	7,350	+3.5%
2004-05	7,300	+2.9%
4-year average	**7,400**	**+4.2%**

The 4-year average milk production was 20,540 litres/ha, with 11,350 litres/ha, (55%), from homegrown grazed and conserved forage (by reverse calculation).

TABLE 2. AVERAGE milk yield, milk composition and liveweight of animals in the M4 farmlet over the 4 years of the project.

Litres/cow/year	7,400
Litres/cow/day	24.0
Milk fat (% and kg)	3.90 and 288
Protein (% and kg)	3.18 and 235
Lactose (%)	5.03
Milk solids (kg)	523
SCC (x 1,000)	226
Liveweight (kg)	561

Figure 3 and *Figure 4* present daily herd and average litres/cow milk production patterns for the scaled up 360-cow M4 herd, with its 35% spring and 65% 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, M4-style herd.

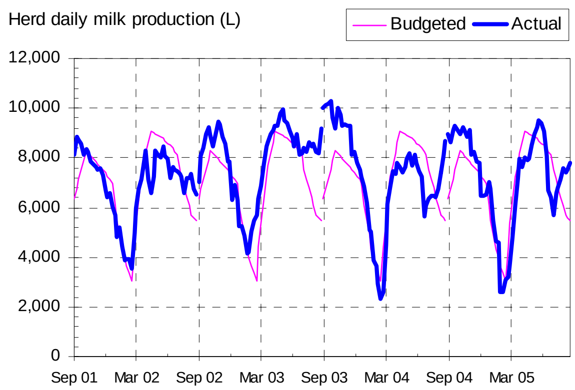
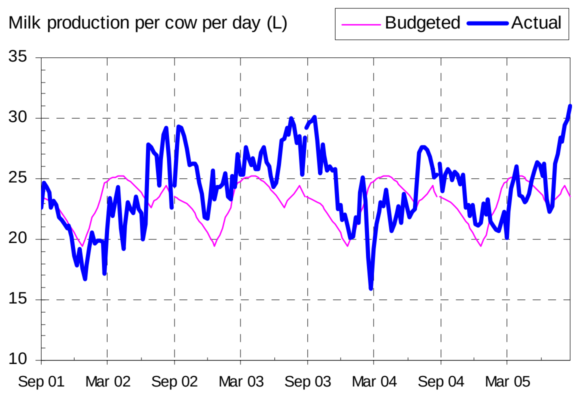


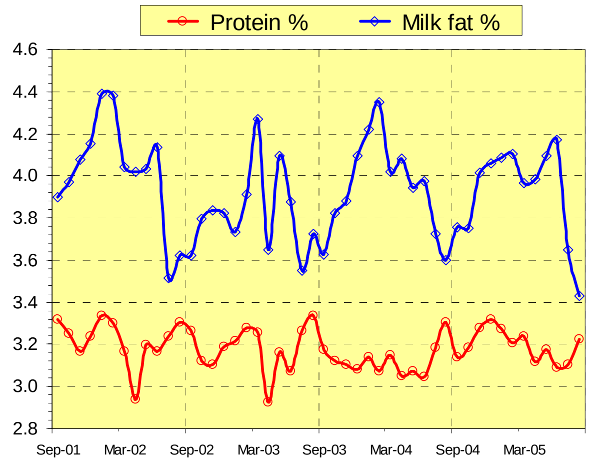
FIGURE 4. DAILY milk production pattern (L) per cow in a 360-cow, M4-style herd.



Milk composition

Milk composition for the M4 farmlet is presented in *Figure 5*. 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 M4 farmlet herd over the four years of the project.



Calving pattern and reproduction

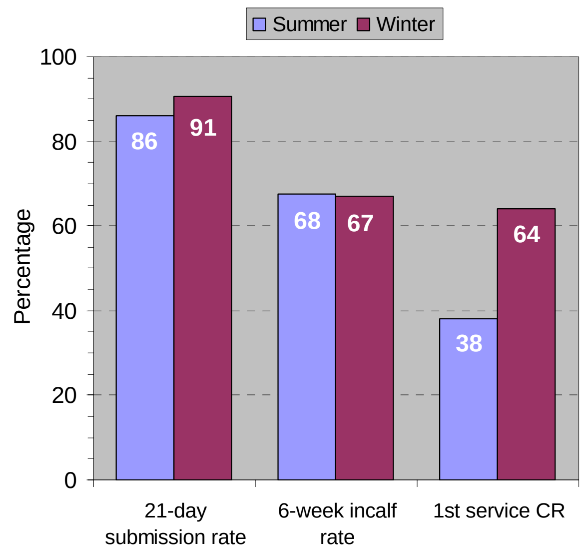
THE M4 farmlet seasonally calved 35% of the herd in spring (with summer mating) and 65% in autumn (with winter mating).

The 12-week summer mating period was planned for 20th November to 12th February, for 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.

With the majority of the herd calving in autumn, the M4 generally recorded good reproductive performance, and a low replacement rate for failure to recalve in the following season.

However the M4 herd struck similar problems to other farmlets in maintaining a spring-calving batch – as demonstrated by the 38% first-service summer conception rate in *Figure 6*.

FIGURE 6. M4 FARMLET herd summer and winter 21-day submission, 6-week in calf and 1st service conception rates (%).



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.

Pastures and crops

THE forage plan for the M4 farmlet (*Table 3)* needed to be flexible to adjust to changing rainfall and irrigation availability**.**

TABLE 3. PERCENT and area of forages on a 130 ha modelled M4-style farm.

% area	ha	Forage type
35%	45	Ryegrass-forage sorghum
31%	40	Prairie-ryegrass-lucerne-clover
19%	25	Lucerne (oversown with ryegrass)
15%	20	Rhodes grass (raingrown)
100%	**130**	**Total farm milking area**

Lucerne and perennial temperate pastures were incorporated as important components of the feed plan, with the intention of providing valuable grazing in the 10 to 12-week establishment periods between summer and winter crops and pastures.

Lucerne and perennial temperate pastures also lend themselves to conservation.

However both pasture types have their weaknesses. Wet conditions of January 2004 and an extended period of water logging caused plant death in the M4 lucerne stands. As the lucerne could not be replanted immediately, it was decided to implement a winter-summer cropping rotation of oats then forage sorghum for 2004, and to replant the lucerne areas in the 2005 winter. Oats was used in preference to ryegrass, because oats is easier to establish and more productive when irrigation is limited.

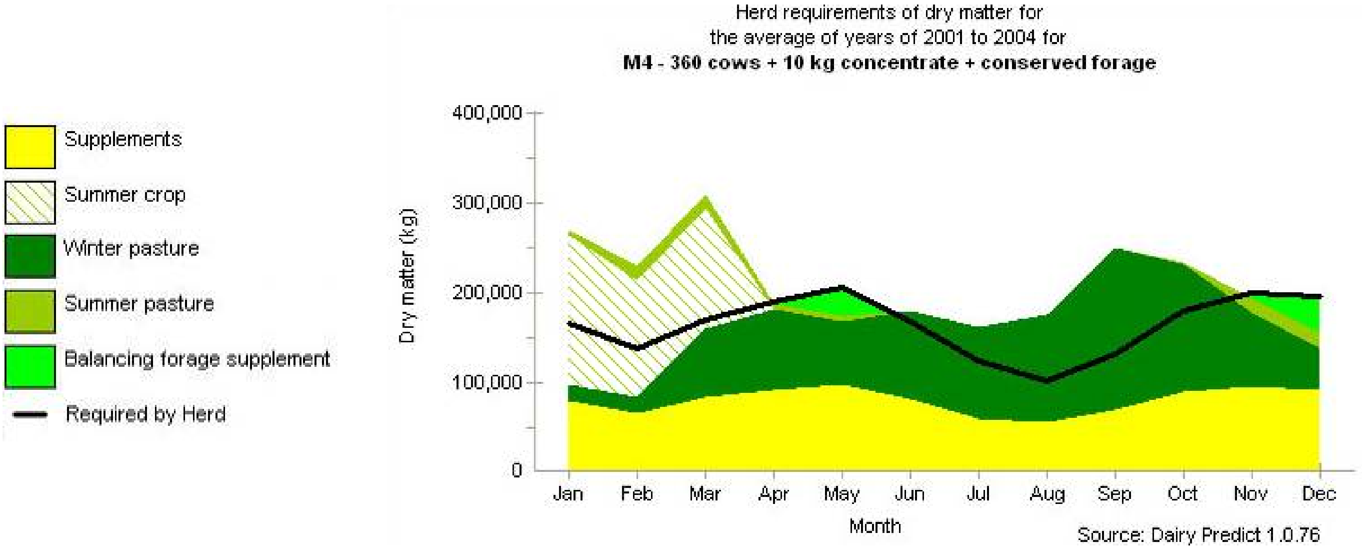
Perennial temperate pastures have low water-use efficiency, so during critical times of limited water, decisions had to be made to irrigate more water-use-efficient crops such as ryegrass in winter and sorghum in summer.

The farmlet stocking rate was 2.8 milking cows/ha over the whole farm, and 3.3cows/ha on the irrigation area. With batch calving there were times of year when dry cows were agisted and the stocking rate on the milking cow area was lower.

Figure 7 represents the M4 farmlet feed plan using the dairy feedbase decision model Dairy Predict. The feed plan shows forage surpluses in summer and winter, and a requirement to feed a small quantity of balancing forage supplement to fill shortages in autumn and spring.

The actual quantity of supplementary forage fed is presented in *Figure 8.*

FIGURE 7. A REPRESENTATION of the forage supply and supplements fed to the modelled M4 farming system produced by Dairy Predict.



Conserved forage - homegrown and purchased

ONE of the priorities of each farming system was to conserve forage whenever possible.

As planned, the majority of budgeted conserved forage for the M4 farmlet was homegrown – in the form of wrapped round-bale haylage, 67% was forage sorghum and the balance temperate species. The quantity fed and the percentage homegrown is presented in *Table 4*. For convenience, quantities are expressed as tonnes of haylage (50% DM).

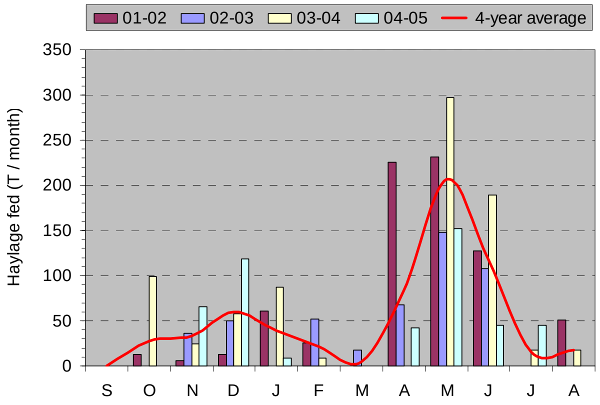
M4 purchased only a small amount of forage, so total variable costs and feed-related costs tended to be lower than the other farming systems. Purchased forage comprised 52% temperate species, 25% roughage (barley stubble and rhodes grass) and the balance forage sorghum.

TABLE 4. QUANTITY of conserved forage expressed as t haylage/cow fed on the M4 farmlet each year and percentage that was homegrown.

	01-02	02-03	03-04	04-05
Tonnes haylage/cow	1.2	0.8	1.3	0.8
% homegrown	65	83	98	80

Handling, storing and feeding out a large amount of conserved forage is an issue with this system. On average 630 tonnes of haylage @ 50% DM (480 to 800 tonnes/year) was fed each year, mainly in autumn. In the 20-cow farmlet herds, all forage was fed in the paddock in ring feeders. A 360-cow herd would need to consider the option of a mixer wagon and feed pad to reduce wastage and manage effluent. If maize silage was used in the production system rather than haylage, then 830 (range 630 to 1,100) tonnes would be required each year. *Figure 8* presents monthly tonnes of forage fed to 360-cow M4 herd.

FIGURE 8. MONTHLY tonnes of haylage (50% DM) fed to the M4, 360-cow herd in each year of the project and the 4-year average.



Fertiliser use

TABLE 5 presents the quantities of nitrogen fertiliser applied to forage areas on the M4 farmlet. Low rainfall was a reason for lower N applications in some years and irrigation was restricted on the lucerne and prairie mixtures, so less fertiliser was used in those years.

TABLE 5. NITROGEN fertiliser applications (kg N/ha) for each pasture and forage type on the M4 farmlet.

Forage type	Kg N/ha applied in year				Average
	01/02	02/03	03/04	04/05	
Ryegrass-sorghum	282	253	230	307	268
Prairie-lucerne mixed pasture	219	77	-	107	101
Lucerne-ryegrass	105	18	76	90	72
Rhodes grass	92	276	147	201	176

Table 6 presents the amounts of N applied to the M4 farmlet per cow per year. By industry standards, the average N fertiliser use of 59 kg/cow/year on the M4 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 - 166 kg N/ha/year or 60 kg/cow/year, equivalent to the quantity of N applied/cow as fertiliser - some of this N would have been redistributed to paddocks in dung and urine.

TABLE 6. NITROGEN fertiliser (kg/cow/year) applied to the M4 farmlet.

	Year				Average
	01/02	02/03	03/04	04/05	
Kg N per cow	72	57	42	67	59

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 M4 high-irrigation farmlet was designed to have 85% of the farm irrigated, consistent with farms with a similar forage system. The irrigation allocation was 6.0 ML/ha or 1.8 ML/cow.

TABLE 7. IRRIGATION water allocation and use in the M4 farmlet.

Allocation		% allocation available		
Per ha	Per cow	02-03	03-04	04-05
6.0	1.83	95	46	82

Irrigation records were available for three winter-summer seasons (April to March) from 2002 to 2005 *(Table 7)*.

- In 2002-03 irrigation was relatively unrestricted, and the farmlet received 85% 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 irrigation season reduced.
- In 2004-05 irrigation use was back to normal, and M2 received 73% of its allocation.

Over three years of data collection, the M4 farmlet received 71% of its water allocation, equivalent to 4.27 ML/irrigable ha, 3.62 ML/farm ha or 1.30 ML/cow

To manage reduced water allocation, less water was applied to the less water-efficient perennial temperate pasture, allowing close to normal irrigation application to the more water-efficient, high-yielding forages - summer forage crops and annual ryegrass.

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 water use efficiency (tonnes DM/ML effective rainfall + irrigation) for irrigated forages in the M5 farming systems project are given in *Table 8*.

TABLE 8. AVERAGE DM yield (t DM/ha) and WUE (t DM/ML) of forages in the M4 farmlet.

Forage type	Yield	Effective rainfall + irrigation	WUE
Ryegrass	9.2	5.3	1.8
Perennial temperate mixtures	9.9	8.8	1.1
Forage sorghum	16.6	4.6	3.6
Rhodes grass	6.7	4.0	1.6

Some annual results from M4 indicating potential WUE were:

- Annual ryegrass: WUE 1.8 t DM/ML, yield 10.3 t DM/ha from 5.8 ML (effective rain + irrigation) in winter 2003.
- Lucerne mixture: WUE 1.4 t DM/ML, yield 12.8 t DM/ha from 9.3 ML (effective rain + irrigation) in 2003/04.
- Forage sorghum: WUE 4.1 t DM/ML, yield 19.6 t DM/ha from 4.8 ML (effective rain + irrigation) summer 2005.
- Grazed double-crop of annual ryegrass and forage sorghum: WUE of 2.9 t DM/ML, yield 28.8 t DM/ha from 9.9 ML (effective rain + irrigation) 2004/05.

Of the grazed farmlets, over three years of measurement, the M4 farmlet produced the most milk from homegrown forage under very dry seasonal conditions - 11,510 litres/ha.

The M4 farmlet also recorded the highest amount of water used per cow for the project, 1.3 ML/cow.

As with other farmlets, the M4 farmlet highlighted the difference in water-use efficiency for forage production between tropical and temperate forages, with irrigated grazed temperate forages ranging from 1.1 to 1.8 t DM/ML, and irrigated forage sorghum 3.6 t DM/ML.

Water-use efficiency of milk production

WATER-USE efficiency for milk production is litres of milk from homegrown forage/ML water (rainfall + irrigation). A litre of milk from homegrown forage is a calculated figure based on total milk production, adjusted for supplements and purchased forage.

Figures for each farmlet are presented in *Table 9*. Based on rainfall and high irrigation, the M4 farmlet recorded a water-use efficiency for milk production from homegrown forage of 1,260 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 (rain + irrigation) water. The M4 (full irrigation) and M2 (limited irrigation) grazed pasture farmlets produced similar amounts of milk/ML under very dry seasonal conditions.

Concentrate feeding

THE M4 farmlet feed budget incorporated 3 tonnes of grain concentrate/cow/lactation (10 kg/cow/day, as fed). The project aimed to study the impact of intensifying the common farming systems of the region – including increased levels of concentrate 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 M4 high-irrigation farmlet herd over the four years was 57/43.

The concentrate ration *(Table 10)* consisted of mixed grains, sorghum, barley and wheat; cottonseed and soybean meals 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 M4 farmlet herd (kg/cow/day as fed).

M4 concentrate	kg/cow/day (as fed)
Grain	7.9
Protein meal	0.3
WCS	1.8
Minerals	0.2
Total	**10.3**

As well as feeding higher rates of concentrate, each farmlet used a higher stocking rate than the industry average. Stocking rates for the M4 farmlet were 2.8 cows/ha on the whole farm and 3.3 cows/ha on the irrigated pastures. 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 M4 farmlet herd was fed the concentrate ration as 4 kg of mixed grain/cow/day in the dairy, with the balance of grain and protein meal outside the dairy in troughs twice a day.

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 12.7 c/L. However production was maintained and concentrate costs were spread over a large volume of milk. The M4 farmlet was able to reach and better its high milk production target of 7,100 litres/cow and achieve a positive RoA by being fed to requirements, including 10 kg concentrate/cow/day.

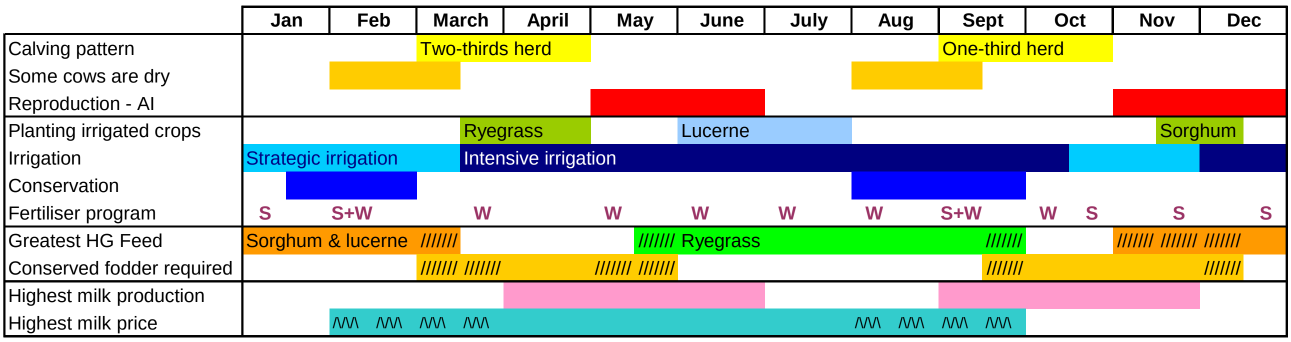
TABLE 11. AVERAGE cost of the M4 concentrate mix over the 4 years of the project.

M4 concentrate cost	01-02	02-03	03-04	04-05
$ per tonne as fed	239	317	223	212

Calendar of operations and farm activities

A YEARLY calendar of operations and farming activities for the M4 farmlet is presented in *Figure 9*.

FIGURE 9. A CALENDAR of farming operations for the M4 farming system.



S = summer, W = winter fertiliser program

/////// = dependant on seasonal conditions

/\/\/\ = varies with processor supplied

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 reviewing. 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 highest on farmlets M1 and M2, which had an emphasis on perennial grass pastures rather than annual crops.

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

A HIGH level of irrigation increases the potential for water and nutrient leakage from the pasture area. Combining deep-rooted species such as lucerne with shallow-rooted species such as ryegrass will reduce this risk.

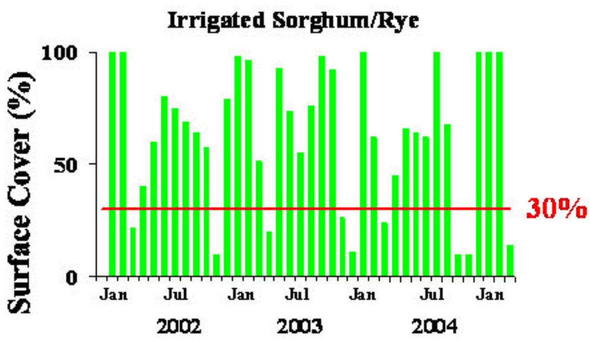
A very high stocking rate in combination with irrigation also raises the risk of soil structural damage through compaction.

Conservation and storage of large amounts of surplus forage in spring and autumn will require well-designed storage, feedout and effluent facilities to reduce the risk of point-source pollution.

Nitrogen-fertilised pastures are vulnerable to loss of N through leaching, and to acidification, especially on well-drained soils. Soil nutrients (to at least 0-10 cm and 10-20 cm depth) should be monitored every two years, and fertiliser use adjusted accordingly; lime should be applied as indicated by soil test results.

Visual estimates were also made of soil cover during summer and winter (*Figure 10)* of the irrigated and double cropped ryegrass-sorghum paddocks. The high level of irrigation in this farming system negates the need for fallow periods to build-up soil moisture. This means that ground cover can be retained year-round, and soil organic matter levels maintained or improved. However, soil cover measurements taken on an M4-style commercial farm reinforced the limitations of traditional tillage practices to prepare seedbeds and control weeds - especially over the erosive summer period. Incorporating zero till practices can reduce this risk.

Figure 10. 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 M4 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 M4, had a positive operational 4-year average return on assets.

Scaling up the production results and costs of the 20-cow Mutdapilly M4 farmlet herd over 4 years, the high-irrigation pasture-based M4 farming system returned a gross margin of $1,128/cow/year, for an average operating profit of $436/cow/year.

Annual business results for M4 are summarised in *Table 16*.

Because this system was able to grow the majority of its forage requirements during the drought, it achieved good business results.

TABLE 14. THE ESTIMATED capital required in 2000-01 to change a typical 125-cow M4 farm (from QDAS) to a 360-cow herd on the same land area.

Extra capital required - M4	**$**
Land	0
Buildings	
Dairy buildings	50,000
Total buildings	50,000
Plant/equipment	
Vat	70,000
Feed pad	9,500
Feed wagon	80,000
Stock water	12,000
Silos	15,000
Effluent	40,000
Total plant / equipment	226,500
Livestock	195,880
PDA / Shares	0
TOTAL	**472,380**

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 M4 farm in QDAS in 2000-01, and the annual and 4-year average figures from the modelled M4 farmlet.

	QDAS	M4				
BUSINESS TRAIT SUMMARY	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**Average**
Liquidity						
Dairy cash surplus ($)	69,700	140,731	190,502	208,740	231,296	192,817
Interest costs per cow ($)	125	162	162	162	162	162
Solvency						
Equity %	80%	64%	64%	65%	66%	65%
Liabilities per cow ($)	1,791	2,312	2,312	2,312	2,312	2,312
Profitability						
Change in Net Worth per year ($)		16,850	32,408	48,252	64,532	40,510
Return on Assets % (operational)	1.5%	4.2%	6.5%	7.4%	8.4%	6.6%
Return on Assets % (Capital+operational)		8.1%	10.8%	12.0%	13.4%	11.1%
Return on Equity %	1.9%	2.5%	6.3%	7.7%	9.1%	6.4%
Operating profit ($/cow)	140	266	422	489	567	436
Efficiency						
a) Capital efficiency						
Asset turnover ratio %	22%	42%	47%	42%	42%	43%
b) Financial efficiency						
Feed related costs (c/L)	12.8	17.0	17.3	14.7	14.6	15.9
Forage costs (c/L milk from forage)		11.9	8.0	10.0	8.4	9.6
Margin over feed related cost (c/L)	21.2	21.7	20.9	23.2	24.3	22.5
Gross Margin per cow ($)	920	983	1122	1172	1235	1,128
c) Physical efficiency						
L / cow / year	5,786	6,971	7,953	7,352	7,303	7,395
L / hectare	5,673	19,363	22,092	20,421	20,287	20,541
Litres / labour unit	387,681	627,359	715,782	661,655	657,307	665,526
Cows / labour unit	67	90	90	90	90	90

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.

Unreliability of irrigation water. Companion farmers that were closely aligned to the M4 farming style at the beginning of the project have tended to shift towards other feed sources and farming systems – due to dry weather conditions, and unreliable and often declining water supplies.

As it has become more difficult to depend on irrigated pastures, this style of dairy farming has become less common. A reliable 600 ML farm allocation is commercially rare today.

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

There has also been a gradual switch from fully-grazed irrigated forage, to a partial grazing/mixed ration combination - with restricted water being more profitably used to grow special purpose, high-yielding, irrigated forage crops such as maize, barley and forage sorghum for silage.

Water use. Farmers are improving the efficiency with which they use 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.

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 applying the water 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.

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

Several irrigation farms have moved from traveller and hand-shift irrigation equipment to solid set or centre-pivot irrigation to reduce labour, to water to pasture requirements (rather than equipment limitations) and to improve water distribution.

Farms relying on irrigated forage are also incorporating moisture measuring equipment such as EnviroSCAN and irrigation scheduling to adjust rotation speeds, application volumes etc and improve their water use. Low-cost tools are available, such as push-rods that determine how deeply irrigation has penetrated the soil profile.

In planning their water, some farmers budget on 3 to 7 ML/ha, others on 1.3 ML/cow – depending on rainfall. The M4 farming system was based on 6 ML/ha and 1.8 ML/cow.

Improving pasture utilisation. Improving pasture utilisation – especially on 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 for improved water-use efficiency and forage utilisation has enabled a higher stocking rate, and a lift in total milk production from the farm.

One southeast Queensland companion farm made adjustments 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. These changes resulted in an improvement of 100% in water-use efficiency and 85% in pasture utilisation.

Seasonal forage feed gaps. While irrigated pastures were planned as the main feed source for the M4 farmlet, feed gaps were predicted for autumn and spring. Many farms are incorporating a wider range of forage species to bridge these seasonal feed gaps. Deep-rooted perennial herb species such as plantain and chicory have proved to be more drought-tolerant and persistent than other temperate species. Short-term high-yielding crops such as brassica for autumn and spring, and forage sorghum in summer are being tried by some farmers.

Labour and lifestyle. Lifestyle and not 'overworking' was an important consideration for factoring in extra labour as this farming system intensified. Farmers had the basic skills required to intensify their systems, but these skills needed upgrading.

Managing irrigation requires extra labour. Companion farmers questioned the ability of this high-labour system to return 600,000 litres/labour unit – which equates to around 90 cows/ labour unit.

There was general consensus that the system would need to budget for more labour – at least five labour units for the described 360-cow business size. Four labour units were considered sufficient if heifers were contract reared. Casual labour was considered feasible for undertaking much of the work, including milking.

Increasing labour requirements raised the issue of sourcing, managing and retaining good labour, and the need to budget for decent wages and conditions.

Business considerations. Companion farmers reflected that maintaining and running irrigation equipment comes at high cost. Changing to a more efficient irrigation system is also costly. The cost of water and irrigating increases the importance of using available water efficiently.

Companion farmers felt this high-production, intense system was commercially possible (with stable water supplies) - with the input of 3 tonnes of concentrate/cow/year - and that 7,500 litres/cow was feasible.

Most companion farmers believed the extra debt of $500,000 was not large for the returns that would flow from expanding the system – but it would depend on attitude to borrowing and existing debt levels on individual farms. An equity level of 65% is much lower than the majority of farms are used to.

Confidence in future milk prices is required before expanding a complicated, high-input system such as M4.

Infrastructure. Farmers were aware that intensifying this farming system further would require an upgrade of most farm facilities to ensure sustainability and ease of management – including likely upgrades to the shed and milking machines to handle extra cows; larger milk vats; a better tractor; improved laneways, shade, fences and water troughs; a larger covered and concreted feed pad; a large loafing area for 360 cows; and improved effluent facilities at the dairy and feed-out area.

Sustainability. 'Pushing' this farming system will create environmental issues with increased cows and increased manure. The appearance, smell and potential pollution risks will need to be well managed.

Environmental sustainability and flexibility of this style of farming can be improved with the use of minimum or zero till – with the benefits of quick turnover between forages, cheaper establishment and improved soil and moisture retention.

Success of a high-irrigation system depends on favourable seasons – neither too wet nor too dry, and favourable access to reasonably-priced supplementary feed sources.

Staging and phasing expansion. Farmers believed that expansion of this system should be via phased, incremental changes over at least 3 years. They believed it was important to 'push' the existing system to its limits - including making best use of the feed that you already grow - before intensifying further. The aim would be to firstly raise existing production to 7,000 litres/cow, before increasing cattle numbers.

Some farmers thought that cattle numbers and concentrate feeding levels should then be increased before a mixer wagon and feed pad were considered. Others believed it important to build and acquire the required infrastructure, before increasing cow numbers and changing feeding systems.

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

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 a defined 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 to 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 plus 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.

All irrigation farmers are recognising the need to make maximum use of the pastures and forages that they grow and irrigate. Many see a 'cut and carry' system as a better way to maximise utilisation of their irrigated forages, so have incorporated a mixer wagon for that purpose. However, some companion farmers still questioned the need and expense of including a mixer wagon if 600 ML of water were reliably available for irrigation.

CONCLUSIONS AND RECOMMENDATIONS

Business considerations. There appears to be potential for increased production per cow on all pasture-based farms in the subtropical dairy region. 2005 QDAS data indicates average production per cow in northern NSW is 5,247 litres/cow/year and in SEQld it is 5,385 litres/cow/year. The Mutdapilly M4 high-irrigation pasture farmlet averaged 7,400 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 sometimes have to operate as raingrown dairy farms - so the management options raised by the raingrown M1 farmlet are also pertinent to M4-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 – are magnified in a more intensive system.

Intensifying a pasture-based system makes it 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. Milk production was dramatically reduced between December 2003 and Feb 2004 – when maximum temperatures remained above 30ºC.

Calving pattern. Choose a calving pattern that is the best fit for both feed resources and seasonal milk prices through the year. The 65% autumn-calving batch of cows in the M4 farmlet was designed to match maximum milk production with the period of high autumn/winter milk prices, by calving onto quality temperate pastures.

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.

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 water. Take full advantage of that - including growing and conserving forage during peak periods of growth, for feeding out during low rainfall periods.

Well-grown, well 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.

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

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

Perennial, temperate forages. Based on high quality forage such as ryegrass, lucerne and prairie grass, the M4 faming system would have been able to produce around 1 litre milk/kg of homegrown forage dry matter. However, the dry matter yield of these species is not high, with marginal production in the hot subtropical summer conditions. If the M4 farmlet had relied on these species, forage DM/ML of water would have been much lower than it was, and lower than that of the forage crop-based and tropical pasture-based farmlets.

Conserving fodder. Periods of surplus growth need to be exploited by conserving excess forage. All farmlets – including M4 – had periods of the year when forage did not meet herd requirements. On M4 these anticipated gaps were filled with planned use of homegrown and a small amount of purchased forage.

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.

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

Each farm needs to find a balance between maximizing 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 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 higher water-use efficiency than grazed forage.

Water-use efficiency is improved as forage yield and utilisation increase.

Farming systems 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 annual ryegrass and forage sorghum on the M4 farmlet yielded 28.7 t DM/ha/year.

Concentrate feeding. High levels of grain feeding can be profitable when combined with high production cows, optimum 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 a lower land price.

Environmental considerations. 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.

The higher the level of irrigation, the greater the potential risk of water and nutrient leakage from the pasture area. Combining deep-rooted species such as lucerne with shallow-rooted species such as ryegrass will help reduce this risk.

A very high stocking rate in combination with irrigation also raises the risk of soil structural damage through compaction.

Intensifying the system with a higher stocking rate and a 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 M5 Info series are available at www.dairyinfo.biz on the home page look under,

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CONTACTS

Graeme Busby Ph (07) 4688 1254
Email: graeme.busby@dpi.qld.gov.au
Silage production, business and farm management

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

Rob Chataway Ph (07) 5464 8745
Email: rob.chataway@dpi.qld.gov.au
Environmental topics and cropping systems

Ross Walker Ph (07) 5464 8736
Email: ross.g.walker@dpi.qld.gov.au
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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Mutdapilly Research Station, 4200 Webers Road, MS 825, Peak Crossing, Queensland 4306
Phone: (07) 5464 8711 Facsimile: (07) 5487 8712

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