TECH NOTE 1

Complementary Forage Systems

More milk from home-grown feed

FutureDairy investigated options to mitigate the ever-increasing limitations imposed by land, water and labour availability and cost in Australian dairying.

A key strategy for farmers is to increase home-grown forage production and consumption. This, in turn, can improve profitability. FutureDairy has proved that forage yields from complementary forage rotations (CFR) can be more than double those of pasture. This has been demonstrated on both research and commercial farms.

Complementary forage systems (CFS) integrate CFR into pasture-based dairy systems. This can be done in many different ways and tailored to individual farmers' needs.

When using forage crops, FutureDairy's approach is to start by setting goals that are based on what is possible (and then determine what is feasible) rather than constraining goals based on known limits to the current farm situation.

FutureDairy has shown that production of ~30,000L milk/ha or ~2,000kg milksolids/ha from home-grown forages and more than 7,500L/cow (>500 kg milksolids) are achievable with only ~1t of concentrate/cow.

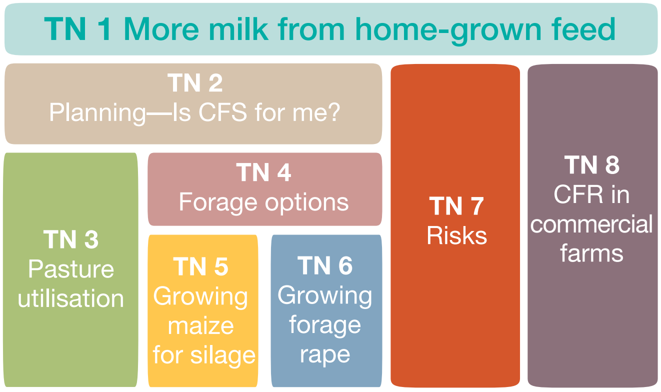
Complementary forage systems may allow you to:

- **Increase total forage yield, and therefore milk from home-grown feed, and farm productivity and profitability.**
- **Replace more expensive bought-in supplements (thus potentially reducing economic risk).**
- **Increase the efficiency of use of nutrients and water.**

This tech note describes:

- **The principles of CFS.**
- **The facts after several years of research at FutureDairy and on commercial farms.**
- **The step-by-step process of implementing CFS on your farm.**

This tech note reports on FutureDairy's findings. Further work/discussion is needed regarding the specific application of these findings in different commercial dairy systems.



Key elements

Complementary forage systems (CFS) integrate forage crops with a pasture-based system. The goal is to increase farm productivity by increasing the amount of feed produced on farm.

Complementary: there is a beneficial impact of combining forage crops with each other and with pasture/s at the soil, plant, animal and/or whole system level.

Forage: both forage crops and pasture are used as key drivers of milk production from home-grown feed.

System: This approach has an impact across the whole farm business system.

FutureDairy has shown these three levels of complementarity through a series of detailed studies that included analysis of:

1. Physical and chemical properties of the soil after four years of CFR (plant/soil level).
2. Rumen characteristics and animal performance of diets comprised of complex mixes of forages and grains as those typical of CFS system (animal level).
3. The way the CFR fits into the pasture system to become a CFS, as described in this tech note (system level).

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CFS Principles

Complementary forage systems can be one of many specific combinations of crops and pasture. They are custom designed to achieve individual farm goals. All complementary forage systems are underpinned by the same four principles.

Principle 1: Need driven

Complementary forage systems can be used to meet a need for additional home-grown feed. They are designed to push the boundaries of milk production from home-grown feed or to reduce the use of more expensive bought-in feed. For example, if the amount of feed produced on farm is not the main limiting factor of your farm you probably don't need a CFS as you don't need to increase feed production. However, a CFS may be an option if you need to maximise feed production from limited land and/or limited irrigation water.

Principle 2: High yielding crops

Complementary forage systems integrate high yielding forage crop rotations into the farm/pasture area (in many different ways). This allows you to grow substantially more forage in one area of the farm (crops) than could be achieved from pasture alone.

Principle 3: Custom design

A CFS must be individually designed for your needs. Complementary forage systems are not a one size fits all set of recommendations in terms of area, proportion of the farm, type and purpose of the crops being used. All these factors will vary across individual farms.

Principle 4: Pasture management

Complementary forage systems enhance pasture management. A CFS cannot be a substitute for poor pasture management and utilisation. Achieving high pasture utilisation is even more important as the total pasture area is reduced under a CFS.

Benefits

The potential impact of a complementary forage system (see Figure 1) includes increased forage production, more milk from home-grown feed, improved nutrient efficiency and risk management.

Increased forage production

Complementary forage systems can help you increase total forage dry matter utilised per hectare. High yielding forage crops can produce more than twice that of pasture alone for a given area of land. Consequently the forage crops can have a significant impact on forage production over the whole farm area even if they are grown on a relatively small proportion (~10 to 20%) of the total farm land. Crops can be grown within the milking area and/or on a separate block of land; for example crops grown for hay or silage can be located outside the milking area.

More milk from home-grown feed

Complementary forage systems can increase the amount and proportion of milk produced from home-grown feed. The extra forage produced can be used to:

- Produce more milk from home-grown feed by either increasing stocking rate or milk yield/cow; and/or
- Reduce concentrate intake per cow and per hectare.

The effects on milk yield per cow result from the use of forage crops with higher nutritive value than pasture (e.g. brassicas crops in early autumn in systems based on kikuyu pastures in NSW and Queensland). Bulk yield crops such as maize or sorghum can reduce total quality if not properly grown and managed (see other tech notes in this series).

Improved nutrient efficiency

Complementary forage systems can improve the nutrient use efficiency on your farm. Efficient cropping provides an opportunity to substantially increase the efficiency of nutrient use (such as nitrogen) and water use (more detail below). This doesn't just occur at the paddock scale, but also at the whole system level.

A CFS study at Camden achieved more than 45% nitrogen (N) use efficiency compared to the national average of 28% (Gourley et al 2010). Nitrogen efficiency is the total amount of nitrogen outputs in relation to total nitrogen inputs (see below).

Note: Results from the Camden study were published in Grass and Forage Science (Garcia et al. 2008).

Risk

Complementary forage systems can reduce risk. There are both physical risks and business risks.

If you use a CFS to increase home-grown forage production on your farm, you are likely to be less affected by seasonal feed shortages and have more control over the feed you will produce. If you use a CFS to reduce your dependency on more expensive concentrates, you will be less affected by fluctuations in concentrate price (i.e. decrease business risk). On the other hand any additional capital investment that may be required in your particular situation, such as a mixer wagon, feedpad, will increase business risk.

Terminology

Complementary Forage System (CFS) refers to the whole farming system; that is the combined pasture and forage cropping area; **Complementary Forage Rotation (CFR)** refers to the area allocated to double or triple cropping.

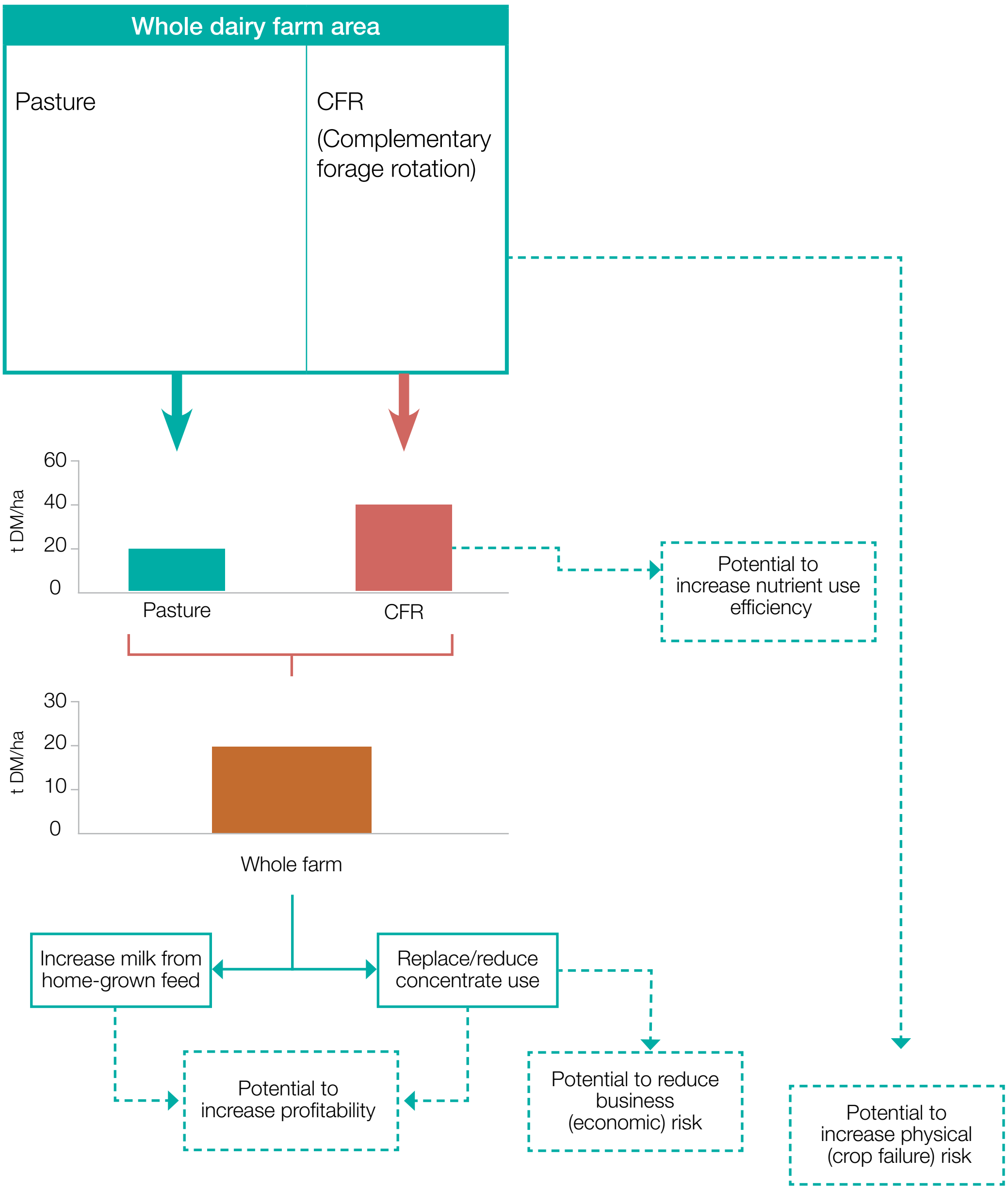

Figure 1. A diagramatic and simplified representation of a Complementary Forage System (CFS) and its potential impacts on farm.

The main physical risk associated with a CFS is crop failure. Forage crops occasionally fail but higher control of nutrient and water can increase feed production security (i.e. decreasing physical risk).

Farmers using a CFS see this technology as ‘less risky’, as they have more control over the feed they produce on farm (see the Hunter Valley case studies, published with this tech note series).

What's possible?

FutureDairy investigated in detail the effects of a CFS on the whole dairy farm system. The following results indicate what's possible, raising the bar well above industry standards.

Whole farm

In a whole farm system study conducted at Camden, FutureDairy proved that the following achievements are possible (see Tables 1 and 2):

- > 20t DM/ha/yr pasture utilisation under irrigation.
- 37t DM/ha/year yield from a triple-cropped area.
- Almost 30t DM/ha yield from a double-cropped area of the farm.
- >25t DM/ha annual total net forage utilisation over the whole farm (from a farm comprised of 35% of the area with CFR and 65% with pasture).
- >27,000L milk/ha (milking area) from home-grown feed.
- 45% nitrogen efficiency across whole farm (60% higher than the national average).

The higher nitrogen efficiency resulted from the combined effect of:

- Relatively moderate amounts of nitrogen applied (~400kg/ha) in comparison to other FutureDairy experiments).
- The high yield of forage and particularly maize (low in nitrogen content).
- The relatively high yield per cow (>7,500L) with only 1.1t concentrate per cow.

Note: Results published in Animal Production Science (Farina et al. 2011).

The lower yield of maize in the double-crop area was likely attributed to the lower amount of nitrogen used in that rotation (~200 kg N/ha were applied to the forage crop in the triple-crop rotation but not to the clover in the double-crop rotation).

Table 1. Mean area (ha) and forage utilised (consumed by the cows or harvested, t DM).

		Amount utilised (t DM)	
	Area (ha)	Per ha	Total
Pasture	13.2	22.4	295.0
Triple crop area	4.15		
Forage rape		7.1	29.3
Legume (Field Peas)		4.6	19.1
Maize		25.3	104.8
Total Triple Crop area	4.15	36.9	153.1
Double crop area	**4.15**		
Legume (Persian clover)		8.0	33.2
Maize		20.8	86.1
Total Triple Crop area	4.15	28.8	119.3
Total farm (utilised home-grown feed)	**21.5**	**26.4**	**567.5**

Notes: Total crop area was 8.3ha. Half of this area was used with a triple crop (3x) including maize, forage rape and a legume (typically field peas). The other half was used with a double-crop (2x) rotation of maize followed by Persian clover. Values are means of two years.

Table 2. Mean annual milk and milk solids production (total and from home-grown feed).

	Milk	Fat		Protein	
	(L)	(kg)	(%)	(kg)	(%)
Milk/cow (305 days)	7,738 ± 97	323 ± 4	4.10 ± 0.04	273 ± 10	3.57± 0.14
Milk/ha (total, L/ha)	34,499	1,445	-	1,231	-
Milk/ha (from home-grown forage, L/ha)	27,831	1,166	-	993	-

Note: Results published in Animal Production Science (Farina et al. 2011).

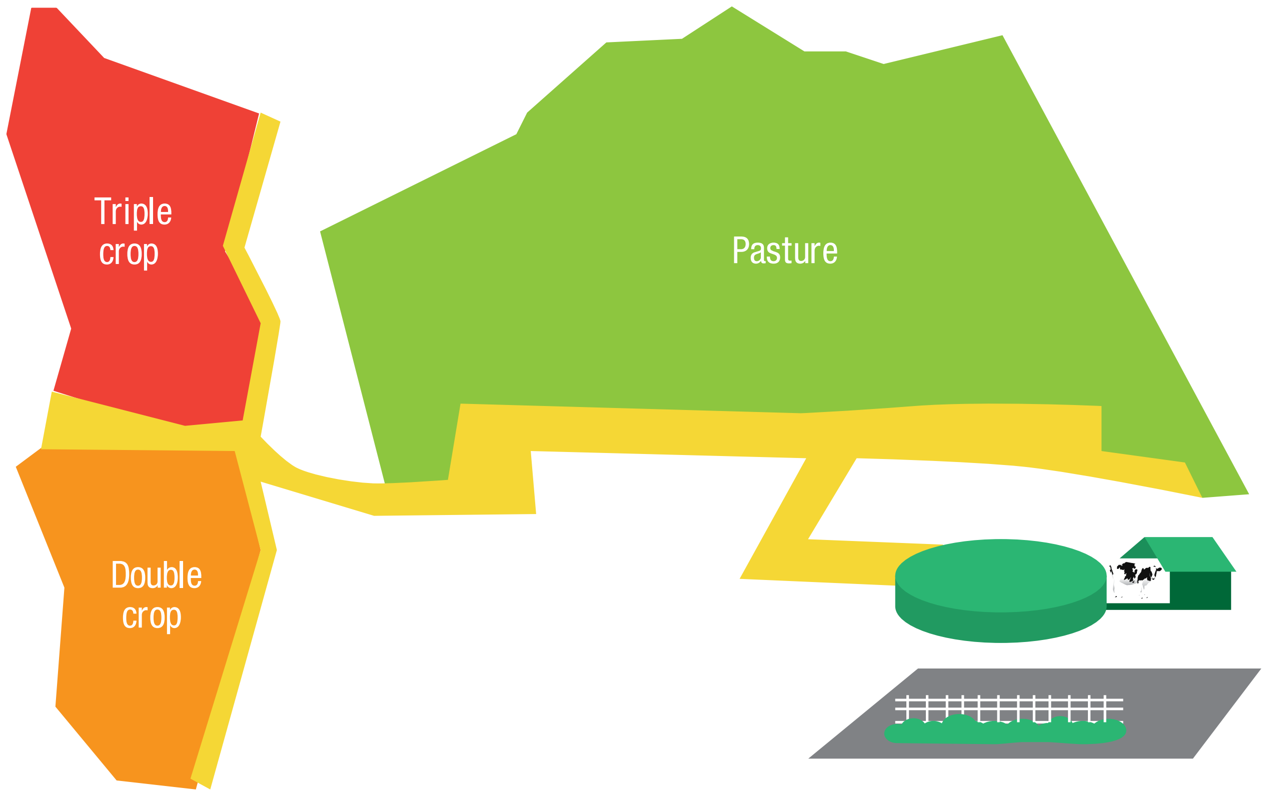

Figure 2. FutureDairy's CFS whole farm system experiment at Corstorphine, Camden, NSW.

FutureDairy approach

These results were achieved by allocating 35% of the milking area to cropping and 65% to pastures (the dry cows were managed outside this area). About half of the 35% of the cropping area was used with a triple-crop complementary forage rotation comprising maize for silage, forage rape (brassicas) and a legume (Persian clover or field peas). The other half was double cropped, with maize for silage followed by Persian clover (see Figure 2).

CFS area

There is no one single or 'best' crop combination or ratio of cropping and pasture areas. The design is determined by your production goal.

In the Camden study, the proportion of forage crop and pasture areas (35:65) resulted from a forage planning exercise designed specifically to achieve a target of 30,000L milk/ha from home-grown feed.

For example, if you are planning to increase milk production from 12,000 to 20,000L/ha, you may need only 20% or less of the total area in forage crops. Double cropping (summer followed by autumn-winter crop) may be all that is needed. Figure 2 shows that the 'cropping' does not need to be within the milking area; for example it could be a double or triple cropping outblock with a 100% harvestable forage rotation.

In most cases the forage crop area will vary between about 10% and 40% of the total farm area. An area less than 10% will result in little or no significant impact on total feed utilisation on farm. Conversely, an area greater than 40% may require more dramatic changes in your system (e.g. you may need to feed total mixed ration at some times of the year due to the significant reduction in the pasture area). For example:

- Less than 10%: you may harvest more than 25t DM/ha from a maize crop and another 10t DM/ha from an annual ryegrass after the maize, but if this area is only 5% of your total farm the combined 35t DM/ha yield will be too 'diluted'.
- More than 40%: the stocking rate over the pasture area will at least double from about October to April or even longer if your pasture-system is based on annuals such as oats or ryegrass. This may result in cows being fed completely without pasture for a couple of months, an undesirable situation if not properly planned. This is particularly important for large-herd farms, as finding space and feeding more than 400 cows without grazed pasture can be very challenging.

CFS planning

If you want to increase the productivity of your dairy operation, the first decision is whether a CFS is an option for you. The following steps can help you answer this question.

1. Set goals

Set your business goals. The CFS technology can help you lift productivity on farm significantly, but if this is not your goal, then a CFS is not for you. This is by far the most important step. The use of return on assets (ROA) is recommended for setting business goals.

2. Set physical targets

Set the physical (production) goals that will enable your business goals to be achieved (e.g. how much total milk you need to produce and at what cost; and therefore how many cows and how much milk per cow you should aim for). This will normally imply going from point A (current situation) to point B (improved situation).

3. Plan the system

Once you know how much milk you need to produce to achieve your business goals, you are ready to plan your system. This does not need to be to a great level of detail. Gross figures of seasonal energy demand and how these will be covered by different combinations of crops and pasture are all that is needed. FutureDairy has established a planning process to help you do this (see the planning tech note in this series).

4. Choose crops

The planning process will help you determine what combination of crops you need to grow to achieve your production goal. The next step is to concentrate your efforts on growing these crops well! Forage crops are typically costly and you need to achieve the yield you are targeting.

5. Pasture utilisation

Ensure you achieve high levels of pasture utilisation at all times. Growing forage crops can help you increase total feed production, but this gain can be eroded completely by poor pasture management and utilisation.

6. Monitor results

Monitor your system. Did you achieve the yields you planned for? If not, what went wrong? And what can you change in your management to avoid similar results next season?

Forage utilisation

Pasture utilisation

Total annual pasture utilisation is the net amount of pasture dry matter consumed by the animals directly or as conserved feed (see Pasture Utilisation Tech Note of this series).

Pasture utilisation can be increased while using forage crops or you can increase pasture utilisation without the introduction of forage crops. Pasture utilisation has a direct impact on profitability so always aim to increase pasture utilisation on your farm first.

To get started, determine the current level of pasture utilisation on your farm. Compare it to the potential based on FutureDairy's results.

On average, the maximum potential pasture utilisation in cool and warm temperate climates is about 18t DM/ha under irrigation and about 11t DM/ha in dryland conditions (Figure 3).

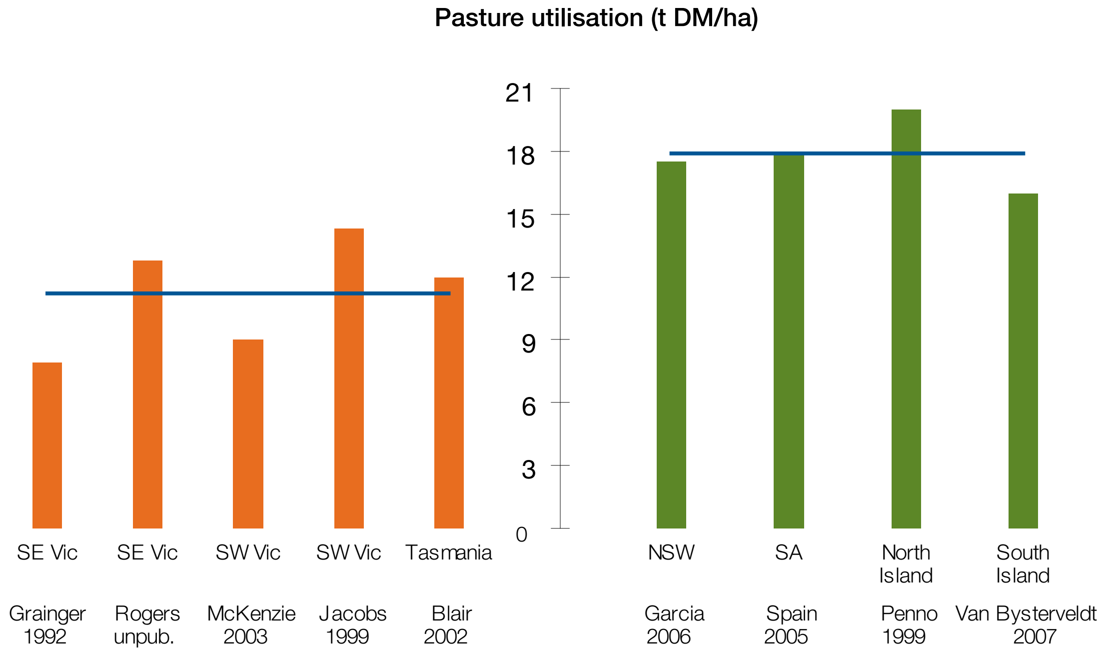

Figure 3. Annual pasture utilisation (t DM/ha) with (right hand side) and without (left hand side) irrigation.
Note: these results have been published in Proceedings of the Australasian Dairy Science Symposium (Garcia et al 2007).

Table 3. The amount of pasture utilisation achieved in different experiments at Camden, NSW.
Note: these results have been published in different international journals.

	Type of experiment			
	Small plot (cut)	Small pot (cut)	Paddock (grazing)	Whole farm (farmlet) (grazing)
Pasture type	Perennial ryegrass (average of 2 years)	Kikuyu (average of 2 years)	Kikuyu oversown with annual ryegrass annually (average of 3 years)	Kikuyu oversown with annual ryegrass annually (average of 3 years)
Total yield (t DM/ha/year)	~22	~25	~18	~20
Source	Neal 2011	Neal 2011	Garcia et al 2008	Farina et al 2011

Table 4. Forage utilisation (maize harvested for silage) of CFR and pasture at Camden experiments (EMAI, 2005–2008).
Note: these results have been published in the international journal Grass and Forage Science (Garcia et al. 2008).

	CFR				
Year	**Brassica**	**Legume**	**Maize**	**Total**	**Pasture**
1	12.0	3.5	26.6	42.1	17.3
2	10.1	4.6	26.2	40.9	18.0
3	11.6	3.9	29.2	44.7	18.4
Mean	**11.2**	**4.0**	**27.3**	**42.7**	**17.9**

Camden results

FutureDairy achieved 25t DM/ha/year in small plots where all factors (except temperature) can be controlled, with temperate species (perennial ryegrass) and subtropical species (kikuyu), but the yield was not sustained in subsequent years.

Yields of 12t DM/ha/year under limited irrigation and 18 and 21t DM/ha under full irrigation were consistently achieved by FutureDairy over several years at both paddock and farmlet levels (Table 3).

Once pastures are established, with good weed and pest control, the key to success is optimising the use of inputs (nutrients and water) and outputs (when, how and what to graze or harvest).

It is essential to maintain a highly productive forage system (the 'pasture factory') across all seasons of the year. This is achieved by applying key management rules to ensure adequate management of pre- and post-grazing pasture mass. This will ensure maintenance of the highest possible pasture growth rate and also cows' intake (see Pasture Utilisation Tech Note of this series).

Crop rotations

If you think a CFS is an option for your farm, there are many forage crops to choose from. Crops can be used for different purposes (e.g. increase forage production, increase forage quality in summer) but the greatest benefits occur when you plan and use forage crops that suit your needs. Maize and brassicas have the greatest potential to impact on total feed produced on farm in NSW and Qld dairy regions.

FutureDairy has investigated these forage crops in detail and developed management guidelines (see tech notes in this series on brassicas and maize).

At Camden, NSW, FutureDairy has achieved yields of more than 42t DM/ha from a forage rotation. In this particular case the forage rotation comprised grazable forage rape (brassicas), grown together with an annual clover (or before field peas) and maize for silage. These production levels were consistently achieved on the same paddocks over three consecutive years (Table 4).

In addition, the forage rotation was consistently more efficient in terms of nutrient (particularly nitrogen) and water utilisation compared to a well managed and high producing pasture (18t DM of utilised pasture). Refer to the tech note in this series: forage options for CFR.

On-farm results

When small plot scale experiments are scaled up to the paddock level (and subsequently to the farmlet and commercial farm scale), it is often difficult to achieve the same yields. Figure 4 shows forage yields from different experiments carried out by FutureDairy at Camden compared to data obtained from commercial farms in Victoria, South Australia and NSW (partner farms and farms working collaboratively with FutureDairy).

It also shows that substantially high forage yields can be achieved on commercial farms in several dairy regions, although the potential yield decreases from subtropical SE Qld and North Coast and Hunter Valley of NSW to Gippsland in Victoria and Mt Gambier in SA.

The Hunter Valley project is a clear example of the application of the same principle/concept (CFS) on very different individual farm situations. This project was a collaborative effort between DPI NSW, FutureDairy and six commercial NSW farmers.

Participating farmers followed FutureDairy principles to achieve the overarching goal of increasing milk from home-grown feed, but with contrasting specific goals and application on farm. Most increased the total amount of home-grown feed. The project gave the FutureDairy team insight into the way farmers make decisions related to feedbase management under different circumstances. Refer to the Hunter Valley farmer case studies published with this series of tech notes.

Costs

In most cases cropping increases both capital and operating investment, which may increase financial exposure or business risk. The impact on total costs depends greatly on the yields achieved. To achieve target yields from a CFS you will need to manage both:

- Technological inputs such as fertiliser and irrigation; and
- Technology of processes such as adequate sowing time etc.

For example, if you buy seed and fertiliser you will pay the same price regardless of when you sow and how you manage the crop. A common mistake behind an excessive cost of home-grown feed is to spend to achieve high yields but only achieve poor yields and poor pasture utilisation instead.

In terms of the economic impact of a CFS, FutureDairy has demonstrated that:

- The cost of a CFS can be similar or even lower than that of pasture. At Camden, the cost of home-grown feed was $100–$150/t DM utilised. These include all costs (seed, fertiliser, irrigation, etc) and also all labour costs based on contractor rates. Costs do not include the 'opportunity cost' of the land use as this did not apply in this case.
- The physical risk associated with poor crop yield can be reduced with good input management. You can have better control of nitrogen and water, two of the key inputs that determine total yield.

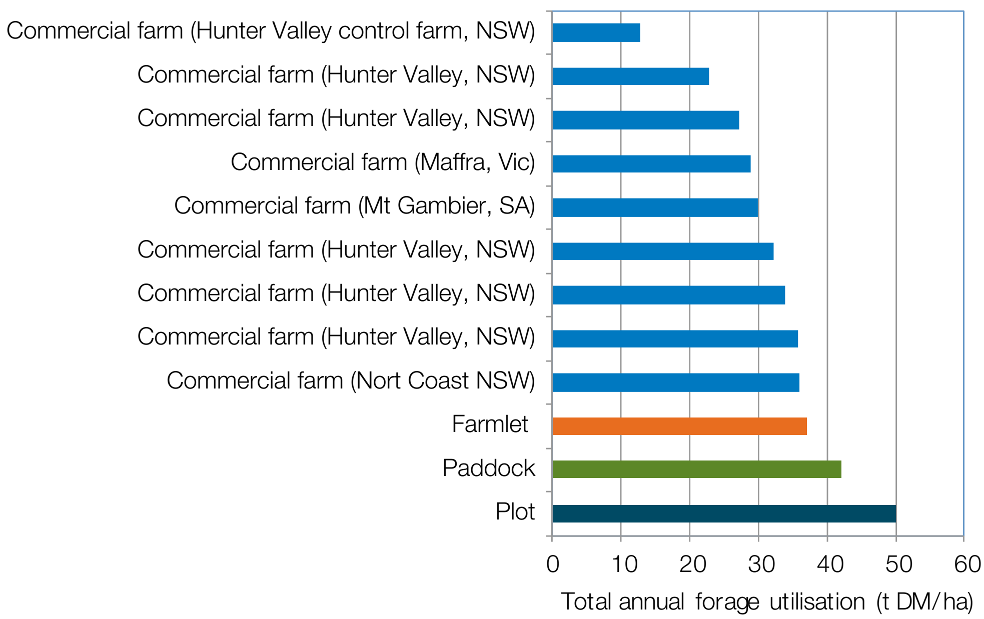

Figure 4. The range in forage yield on CFRs in commercial farms, farmlet and controlled paddock and plot conditions.

- The economic (business) risk can be much lower than a high concentrate plus pasture system. You can use a CFS to reduce concentrate use and therefore the effect of concentrate price fluctuations on farm profit. FutureDairy has demonstrated this through a comprehensive economic-risk analysis based on the data of the three year whole system CFS study at Camden described above. The study included simulation of the climatic and price variability based on historic data.

Note: The study is being prepared for publication and is available from FutureDairy on request. FutureDairy has produced several reports and published papers (Alford et al 2010) into the economic aspects and costs of complementary forages as well as risk (Farina et al in preparation). These papers are available from FutureDairy on request.

To be profitable, a CFS must achieve substantial improvements in total forage produced on-farm. Make sure you have a good support structure such as ready access to good agronomic advice when you need it.

More information

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Copies of these articles are available from FutureDairy. Contact 02 9351 1631 or the Dairy Australia library on 1800 824 377, email library@dairyaustralia.com.au

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