TECH NOTE 3
Complementary Forage Systems
Pasture utilisation

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.

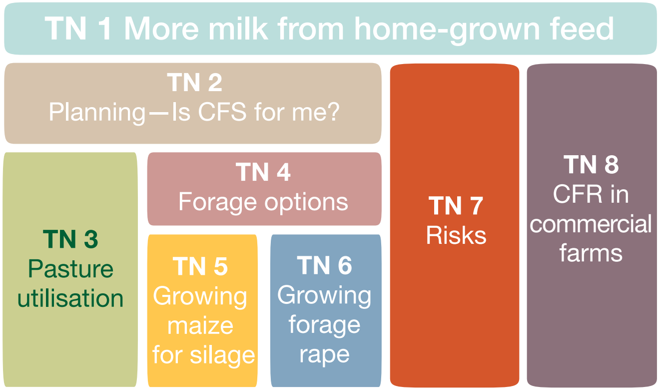
Complementary forage systems may allow you to:

- 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 gives you:

- The principles and practices to achieve high pasture utilisation.
- The step-by-step process used by FutureDairy to achieve high levels of pasture utilisation.

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.



Pasture utilisation is a key driver of dairy farm profitability. High pasture utilisation is possible across all types of production systems and certainly also within a CFS.

Successful complementary forage systems (CFS) rely on high pasture utilisation. A complementary Forage System is NOT a substitute for poor pasture management and utilisation. It is even more important to achieve high pasture utilisation with a complementary forage system because the total pasture area is reduced to make space for cropping.

At Camden, NSW, FutureDairy has consistently achieved pasture utilisation levels of about 12–20 t DM/ha. The lower end of the range was achieved with only 25% of the area under irrigation and higher end was achieved under full irrigation. This is well above the national average which is estimated at about 7–8 t DM/ha (including dryland and irrigated pasture).

The key to achieving high pasture utilisation is to provide enough demand for pasture. FutureDairy's approach to pasture allocation decisions are based on matching pasture removal (grazing and harvest) with pasture growth rate.

This tech note outlines the principles behind pasture growth to help farmers maximise the amount of pasture converted into milk. The principles apply for ALL types of pasture-based systems, from 100% pasture through to an intensified CFS (i.e. pasture + crops).

NSW Government Department of Primary Industries · DeLaval · The University of Sydney · Dairy Australia Your Levy at Work

Key principles

The four key principles of pasture productivity are the same on any dairy farm. They are:

1. Plant growth is dynamic.
2. Growth is related to inputs.
3. If inputs are not limiting, growth is related to amount of plant material present.
4. In most cases you can't change growth but you can change feed demand.

Principle 1: Plant growth is dynamic

Principle: Plant growth is a very dynamic process. New leaves form, grow, mature, decay (senescence) and die if not harvested in time.

Application: Harvest your pastures (by grazing or machine) to match pasture growth rate. This will minimise wastage and maximise utilisation.

The average rate of grazing or harvest should always be as close as possible to pasture growth rate.

The only exception will be when you are purposely building up or eroding total pasture cover, for example before and after calving in seasonal calving systems.

To match harvest rate with pasture growth rate you will need to monitor either biomass, leaf emergence rate, or both.

Implications: To maximise pasture utilisation you will need to systematically monitor pasture growth rate (or alternatively leaf emergence rate). Ideally monitor on a weekly basis and make adjustments so that the harvest rate matches growth rate which will vary throughout the season. Adjustments could be made by changing the total amount of pasture and supplementary feeding allocated to cows on a daily basis.

Principle 2: Growth is related to inputs

Principle: Maximum pasture growth rate requires optimum levels of those inputs that can be controlled by the farmer.

Application: Ensure adequate levels of the two key inputs under your control: nutrients (especially phosphorus and nitrogen) and water.

Implication: Use species that are adapted to your region and soils. Control weeds and pests, especially during pasture establishment. Monitor and optimise application of all key inputs.

Principle 3: Grass grows grass

Principle: The rate that pasture cover increases depends on the amount of live leaf present, which is controlled by your grazing management.

Application: Avoid over- or under-grazing your pastures. This will ensure pasture growth rate is maximised for the conditions and will maintain high pasture quality.

Implication: To maximise pasture growth rate you will need to systematically monitor pastures. This should be done weekly, by monitoring pasture cover on individual paddocks, or by monitoring both pre- and post-grazing cover. If required, adjust the rotation length and/or supplement usage accordingly.

Principle 4: Demand can be changed

Principle: Assuming ideal management, pasture growth rate cannot be changed, for a given species, season and conditions. But you can change the total demand for pasture per hectare.

Application: Use supplementary feed to manage pastures; that is, when a true deficit in pasture quantity and/or quality occurs. This will maximise pasture utilisation and the response to supplements.

Implication: Feed a minimum level of concentrates all year round to balance the herd's diet, increase animal production and improve reproductive performance. Adjust the level of concentrates (and other supplements) to fill the feed gap when pasture growth rate slows and to compensate for changes in pasture quality.

It is crucial to have a high demand to achieve high levels of pasture utilisation. A dairy cow's feed requirements are 4.5–7 t DM/year depending on breed, size and genetic merit for milk production. If your farm is stocked at only 1 cow per hectare you simply can't utilise more than 4.5–7 t DM/ha!

Putting the principles into practice

FutureDairy has identified four basic steps to achieving high pasture utilisation. While many good dairy managers follow these steps, the key to FutureDairy's very high pasture utilisation has been getting each step right, most of the time:

1. Maximise potential growth by managing key inputs (fertilisers and water).
2. Monitor pasture cover (and leaf stage) and from this pasture growth rate regularly and systematically.
3. Allocate pasture based on rate of pasture growth but also adjusting for leaf stage, average pasture cover and target pre- and post-grazing pasture cover.
4. Use supplements to cover true pasture deficit first and to achieve target animals' production level.

This tech note takes you through the four steps above. Appendix 1 provides more details about how pasture plants grow.

Maximise growth

The two key factors needed to maximise pasture utilisation are growing more pasture and utilising more pasture.

Growing more refers to maximising pasture growth (gross growth). This will depend on how much green (photosynthetic) leaf area is present.

Utilising more means minimising decay (losses). This is achieved by removing plant leaves (green tissue) before they decay and die.

Inputs

Once a pasture is established, temperature, radiation, water and nutrient availability are the major factors determining growth for any pasture type. You can't control the first two but there is plenty you can do about water and nutrients.

The 'law of the minimum' applies to nutrient availability and pasture growth. At any given time during the life of your pasture, maximum growth rate will not be achieved if one or more nutrients are limiting.

At all times, provide adequate amounts of macronutrients such as nitrogen (N), phosphorus (P) and potassium (K) and water (if irrigation is possible). This is absolutely essential if achieving maximum growth is the goal!

The amount of these nutrients applied should be based on the balance between total plant requirement and what can be potentially provided by the soil. Comprehensive soil testing is highly recommended. It will enable you to monitor soil nutrient trends and identify optimal fertiliser requirements.

Nitrogen

Results from FutureDairy research conducted at Camden suggest a good rule of thumb is to apply enough nitrogen fertiliser to cover 60–80% of the total annual nitrogen removed by the pasture consumed. Soil analysis will help fine tune within this range. In general the lowest end of the range is for those paddocks that you know have been heavily fertilised in the past (e.g. night paddocks). More nitrogen is likely to be required on paddocks with a poorer fertiliser history and/or lower nutrient loading.

For example, if your target pasture utilisation is 15 t DM/ha, aim to fertilise at a rate of 315–420 kg N/ha (15,000 kg DM/ha x 3.5% N content x 0.6–0.8 = 315–420 kg N/ha).

These general recommendations are in line with those from the Greener Pastures projects in WA, which indicate maximum pasture utilisation with about 1 kg N/ha per day for each season. Ideally you should fine tune this recommendation according to your local conditions (e.g. soil, pasture type, season and weather).

Phosphorus

To get the best response to applied nitrogen, and maximum growth the soil needs a minimum amount of phosphorus readily available for the plants. This critical soil phosphorus level varies widely with both management conditions and soil types. For example, irrigated pastures have higher critical levels than dryland pasture and different soil types vary in their capacity to retain phosphorus (sorption category or buffer capacity). Sandy soils usually have lower phosphorus critical values than heavier, clay soils.

Your local agronomist can help you review soil test results and determine critical levels on your paddocks. Soil tests are also essential to identify other nutrient deficiencies (e.g. potassium and sulphur) and soil chemical (e.g. pH, cation interchange capacity) and physical (e.g. texture, structure, density) properties that may need to be corrected in order to achieve highest possible pasture growth in all seasons.

Recent results from several studies indicate there is a clear excess of phosphorus in most paddocks on Australian dairy farms. This has been found by a national research and development program including more than 40 Australian dairy farms (Accounting for Nutrients), a survey of 20 farms in NSW (Neil Griffiths, personal communication) and a long-term project in WA (Greener Pastures).

The message from all studies was clear: there is no response to phosphorus when soil phosphorus values are above the critical value for that particular soil. Applying phosphorus in these situations in not just a waste of money but also a potentially serious hazard to the environment, as soil phosphorus can contaminate waterways after heavy rain and when soil erosion occurs.

Water

Water is essential to grow pasture and has the biggest impact on the total amount grown. Water has a physical role in cell growth (literally 'stretching' the cell wall to allow cell extension and division). It is also the vehicle for nutrient absorption and transportation within the plant. Plants absorb water from the roots and transpire water as vapour from the leaves and stem, through 'pores' in the epidermis call stomata. These same structures are used by the plant for gas exchange—carbon dioxide (CO_2) and oxygen—in a trade-off process with water. That is, plants need to lose water vapour to gain carbon dioxide.

The more CO_2 carbon fixed by photosynthesis, the greater the potential growth of the plant. But also the more water that needs to be lost. Under water stress the stomata close reducing water vapour loss but consequently reducing carbon uptake as well. This is why water is the main factor affecting pasture growth.

In practice irrigation requirements vary across regions, climates and pasture types. As rule of thumb, for pastures in general, the total need for water (rainfall + irrigation) is 0.6–0.8 ML water/t DM of utilised pasture. For example, if your area averages 600 mm rainfall you should budget to apply about 4–5 ML/ha in an average year to achieve 15 t DM/ha.

If you irrigate, the simplest and most effective approach is to apply water according to soil moisture deficit. Relatively inexpensive soil moisture equipment (tensiometers) can track the amount of water readily available for the plant at different depths. This information will enable you to develop an efficient and economic irrigation schedule to optimise pasture growth.

Growing more pasture

If nutrients are not limiting, pasture growth per unit of area will be directly related to the amount of total solar radiation (and carbon) absorbed. This is in turn is directly related to the amount of green leaf area present. Leaf area index, pasture biomass or 'pasture cover' are measures of the amount of green leaf area present.

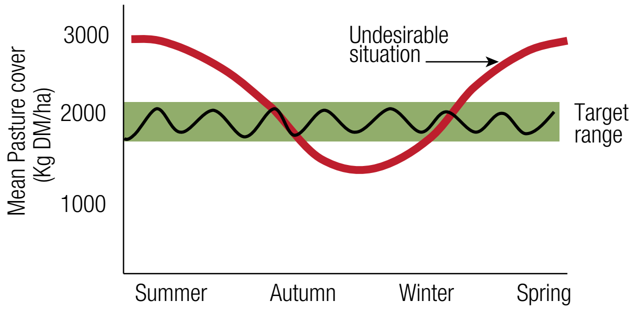


Figure 1. Contrast between a desired management, in which average pasture cover (thin line) is maintained within a relatively narrow range (shaded area) and an undesirable situation in which average pasture cover changes dramatically from very high levels in spring and summer to very low levels in autumn and winter (thick line).

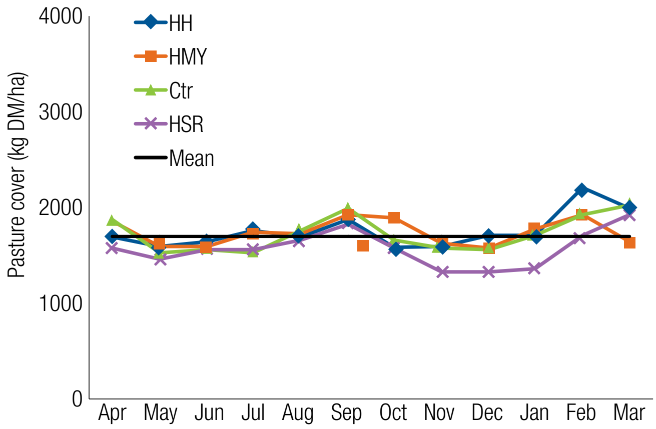


Figure 2. An example of pasture management in which the mean pasture cover was maintained close to target (solid line: 1700 kg DM/ha). The study was a whole system comparison by FutureDairy of four systems (Ctr: control; HSR: high stocking rate; HMY: high milk yield per cow; HH: high milk yield and high stocking rate). For more information see Farina et al. 2011, Grass and Forage Science.

In practice, growing more pasture involves maintaining pasture cover over the whole farm area within a relatively narrow range around a given target (see Figure 1). This target varies among pastures, regions and tools used, but the average of the desired levels of pre- and post-grazing mass would provide a good approximation. For example, if target pre-grazing is 2500 kg DM/ha and target post-grazing is 1500 kg DM/ha, then target pasture cover should be somewhere around 2000 kg DM/ha. These figures refer to pasture cover to the ground level.

This target pasture cover may be a little bit lower in autumn and winter when 'ceiling yield' is achieved at relatively lower pasture cover. Ceiling yield refers to the phase when net growth is nil because the growth of any new leaf is offset by the death of an older leaf of similar size.

Similarly, the target pasture cover may be a little bit higher in spring and summer when ceiling yield is achieved at relatively higher pasture cover.

At times, farmers may deliberately build up pasture cover to 'buffer' the system; for example before calving in seasonal systems. At other times they may reduce pasture cover, such as in late spring or early summer to manage pasture quality.

Generally, the aim is to keep these seasonal variations to a minimum. Figure 1, which shows the contrast between the desirable situation (pasture cover moving up and down within a narrow range around target) and the common situation on many farms, in which pasture cover rapidly decreases during autumn and winter (as a result of poor pasture allocation and overgrazing) and later increases beyond control in spring and summer (again due to poor pasture allocation).

The desired pasture can be maintained around a target range by ensuring that the amount of pasture removed by grazing or cutting balances out, on average, the amount of pasture grown. This is achieved by adjusting the pasture allocation, rotation length and the level of supplements according to changes in pasture growth rate.

Figure 2 illustrates how pasture cover was maintained close to ideal levels in a 2-year trial at Camden. We compared four whole farm systems (farmlets) comprising two stocking rates and two levels of milk production per cow.

Monitor pasture cover

Management of pre- and post-grazing pasture cover is based on the number of growing leaves that a particular species can maintain at any time. For example, perennial and annual ryegrass plants need a minimum of two new leaves per tiller to replenish carbon reserves and decay commences after about three new leaves are developed. This gives a relatively narrow window (minimum two leaves/tiller, maximum three leaves/tiller) to graze the pasture. This concept of using leaf numbers to manage pasture was initially developed by Dr Bill Fulkerson and co-workers in Australia in the 1990's. More recent information from the Greener Pasture project in WA also indicates that delaying grazing from two to three leaves can increase pasture utilisation by 20%, at least in annual pastures (see Greener Pastures Bulletin 4815).

How quickly this window is achieved during regrowth after each grazing depends mostly on the rate of leaf appearance, which is directly related to temperature. The amount of dry matter accumulated over the same period depends mostly on the rate of leaf extension, which is in turn related to temperature, nutrient and water availability and the physiological stage of the plant (vegetative or reproductive). Plant density has an indirect effect as it influences the absorption of solar radiation.

Ensure that your pasture is always maintained within a range to enable maximum growth to occur.

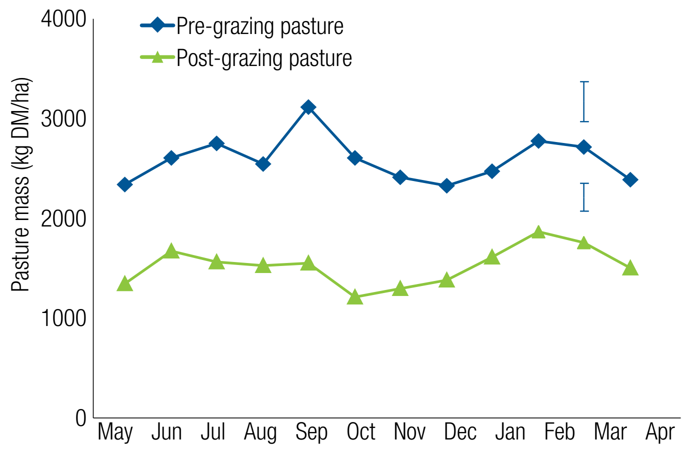


Figure 3: Monthly pre- and post- grazing pasture cover (kg DM/ha) meaned over the two years of the study.

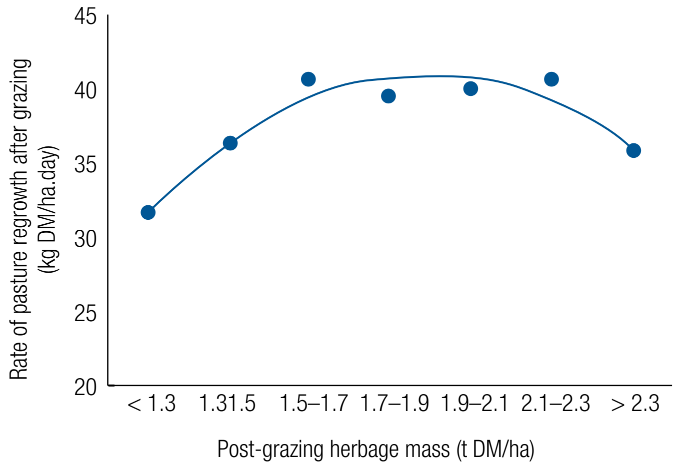


Figure 4. Relationship between post-grazing pasture cover and daily rate of pasture growth during the regrowth period (time elapsed between two subsequent grazing events).

To achieve this:

- Avoid allowing cows to graze pastures too hard. Grazing too hard will decrease pasture growth due to a reduction in gross growth (see below).
- Avoid undergrazing as it will decrease net growth of pasture due to an increased rate of pasture loss by decay.
- Avoid grazing too soon or before the desired number of leaves and/or target pasture cover are achieved (about at least two leaves for ryegrass and three for kikuyu). Grazing before these targets will reduce gross growth and plant survival (particularly in ryegrass).
- Avoid grazing too late (after about three leaves for annual and perennial ryegrass; 4.5 for kikuyu) or past the pre-grazing target pasture cover. Delayed grazing will increase decay of older leaves and reduce net growth and will also affect pasture quality.

The only way to get all this right consistently is by systematically monitoring pasture cover! Figure 3 shows that it is possible to achieve target pre- and post-grazing pasture covers all year round. It is based on data from FutureDairy's CFS whole farm system study at Camden, NSW.

Overgrazing

Overgrazing is the 'silent killer' of pasture growth and utilisation. Managing post-grazing residual is crucial to maintaining high pasture growth rates.

If grazed at an appropriate moment, individual plants can regrow vigorously from reserves even if nearly all leaves were removed by the animals (provided the plants had accumulated enough reserves prior to grazing). During the initial phase of regrowth, however, proportionally more carbon is lost by respiration than fixed by photosynthesis, so a temporary net loss of carbon and dry matter occurs until enough new leaves are produced and the situation reverses (net gain of carbon and dry matter).

From the whole pasture perspective, very little new pasture or pasture cover will be accumulated until there is sufficient leaf area to intercept significant amounts of solar radiation. In practice, pasture regrowth rate depends strongly on the amount of pasture cover remaining after each grazing.

Figure 4 demonstrates the negative short-term effect of overgrazing on subsequent pasture regrowth rate. In addition overgrazing will affect pasture density and persistence.

Adequate management of pre-grazing pasture cover is crucial to achieve desired post-grazing residual. There is a positive relationship between pre-grazing and post-grazing pasture cover: the greater the pre-grazing cover, the greater the post-grazing cover. When pre-grazing pasture cover is higher than 2800–3000 kg DM/ha, it becomes difficult to graze pasture down to desirable levels of about 1500 kg DM/ha.

Allocate pasture

To accurately allocate pasture you need to monitor the average 'pasture cover' of the farm as well as pre- and post-grazing pasture covers.

Pasture cover should be monitored using objective methods such as the rising plate meter or an automatic bike pasture meter. Ideally the monitoring should be weekly, particularly during the fast-growing periods of spring and summer. Ideally, pre- and post-grazing pasture cover should be monitored two or three times per week. In practice the weekly walk carried out for estimating pasture cover can be used to get an indication of pre- and post-grazing pasture cover together with rate of leaf stage development.

The weekly estimate of pasture cover also provides an estimate of pasture growth rate for all the paddocks that were not grazed or harvested over the previous seven days. This estimate of pasture growth rate is an indication of relative changes, not an accurate measure. In practice, consider pasture growth rate with other factors such as weather and soil conditions and your own experience.

The weekly pasture growth rate is best viewed as a trend (i.e. what is happening over the last couple of weeks) rather than as a specific value for a particular week. For example, if pasture cover is within the desired range and average pasture growth rate is close to zero, this should be considered along with other factors (eg weather forecast for the next week, nitrogen inputs, etc.) and it does not necessarily mean that pasture intake should be reduced to zero. However, if the following week average pasture growth rate is again close to zero, then it is a clear indication that pasture allocation needs to be reduced substantially, to prevent a decrease in pasture cover.

A simple way to allocate pasture based on pasture growth rate involves two steps:

1. Calculate total daily requirements. This doesn't need to be a sophisticated calculation but a simple quantification of the herd's needs.
2. Assuming an average dry matter intake of 20 kg/cow.day, a 100 ha farm (effective grazing area) running 300 lactating cows will need to provide cows with about 6000 kg DM/day (300 cows x 20 kg DM/cow).

Allocate pasture based on current pasture growth rate.

In winter for example, if average pasture growth rate is around 20 kg DM/ha.day the total farm area could be considered to grow about 2000 kg DM/day (100 ha x 20 kg DM/ha.day). In this case, if pasture cover is within the desired range, cows should be fed about 33% of pasture in their diets (2000/6000) and therefore can graze only 6.7 kg DM/cow.day.

Figure 5 shows how this was achieved in practice at FutureDairy's whole systems study conducted at Camden, NSW. The graph shows how the rate of pasture intake/ha for four contrasting systems (combinations of two stocking rates and two levels of milk yield per cow) follows the rate of pasture growth/ha closely at the feeding farmlet system study conducted at EMAI (DPI NSW) in 2006–2008. The graph highlights the similarities of the intake rate curves for the four systems in relation to the growth rate curve, therefore the systems have not been identified in the figure.

Matching the rates of pasture growth and pasture consumption is paramount to obtain highest possible pasture utilisation.

Supplements

In the above example the difference between cows' requirements and pasture eaten (20–6.7 = about 13 kg DM/cow) should be covered by supplementary feed. There are 300 cows in 100 ha (3 cows/ha), the actual daily amount of supplementary feed required will be 13 x 300 =3,900 kg DM.

If you feed less supplementary feed than required, your cows will tend to compensate by grazing harder. This will affect total dry matter intake because the amount of DM/bite decreases dramatically with a decrease in residual cover (post-grazing pasture cover). It will also affect pasture regrowth rate and total pasture utilisation as shown in Figure 4.

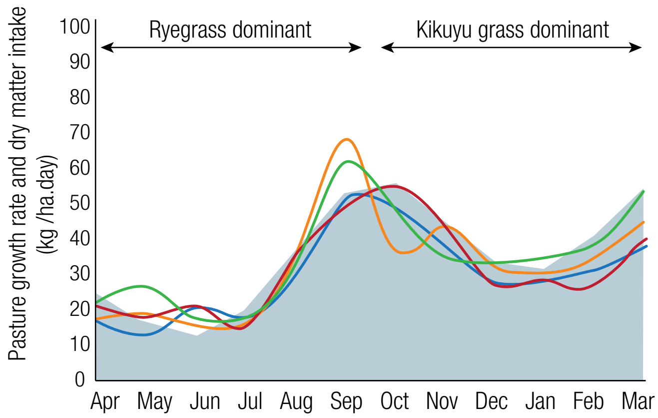


Figure 5. Mean pasture growth rate (grey area) and dry matter intake (thinner lines) both expressed as kg DM/ha.day for four contrasting systems (not identified in the figure), showing that dry matter intake closely followed pasture growth rate in all systems.

In this example if pasture cover is lower than target, part of the current growth rate (about 20 kg DM/ha.day) should be 'saved' to 'recover' pasture cover up to the desired level. In other words manage your pasture to maintain a relatively constant pasture cover within a range of ±200 kg DM/ha.

You will also need to ensure that your cows will not eat more than the target pasture allocation. Continuing with the example, the next question is how do we allocate pasture to ensure cows will eat only 6.7 kg DM/head?

This is where the estimate of pre- and post-grazing pasture cover becomes crucial. If target pre- and post-grazing pasture covers are 2500 and 1500 kg DM/ha, respectively (i.e. a 'net' amount of 1000 kg DM/ha harvested on each grazing), then pasture allocation should be as follows:

- Total amount to be grazed by the cows: 300 cows x 6.7 kg DM/cow = about 2000 kg DM/day.
- Total amount potentially harvested per hectare grazed = 1000 kg DM.
- Dairy area to be grazed per day by 300 cows: 2000/1000 = 2 ha.

As cows will be supplemented with about 13 kg DM/cow of supplements (e.g. 7 kg of concentrate at milking plus 6 kg DM of fodder in the paddock) in most cases they will not graze harder than desired residual (1500 kg DM/ha in this case). You can also use other strategies to prevent this, for example:

- Timing and physical place of feeding supplements.
- The number of grazings each day (i.e. whether cows will graze both morning and night or only once a day).
- The time of moving the cows in and out the paddock.
- Water availability can be used as a tool to manipulate the extent to which a particular paddock/strip is grazed, although its applicability is more limited.

In late-winter and early spring, average pasture growth rate can quickly increase. Within a week or two it can go from 15–20 to 45–50 kg DM/ha/day. Applying the same steps (and again assuming a rough estimate of cows requirements for simplicity) we now have a farm that is producing between 4500 and 5000 kg DM/day, or about 80% of the herd's requirements (about 6000 kg DM/day).

Assuming that target pre- and post-grazing pasture covers remain similar, the calculations are as follows:

- Total pasture grown daily: 100 ha x 50 kg DM/ha/day = 5000 kg DM/day.
- Total requirements: 6000 kg DM/day.
- Total requirements covered by pasture: 5000/6000 = 83%.
- Area to be grazed per day by 300 cows: 5000/1000 = 5 ha.

Rotation length

FutureDairy's approach to pasture allocation is driven by the objective of matching pasture removal (grazing and harvest) with pasture growth rate. Rotation length is not ignored, but it is more a consequence of the applied management rather than an 'input' in the management decision process.

In our management system, rotation length serves as a 'checking factor' to ensure that the decisions fit within the expected range. Under adequate pasture management, rotation length should be the shortest when pasture growth rate is maximum and the longest when pasture when pasture growth rate is minimum.

Farming system

High pasture utilisation is not limited to a type of system.

If pastures are managed following the key principles outlined here, the same level of pasture utilisation should be achieved regardless of the type of cow, production system, stocking rate and level of supplements (although this does not mean that all systems have the same level of profitability). This relies on an adequate stocking rate (medium–high) to create enough feed demand per hectare.

In one of FutureDairy's whole system experiments, four systems with contrasting milk yield per cow and stocking rates achieved the same level of total pasture utilisation: about 11 t DM/ha over whole farmlet area with irrigation limited to 25% of the area in summer. They also achieved similar average pre- and post-grazing pasture covers despite having contrasting stocking rates (Table 1).

Using the same management rules under full irrigation, FutureDairy achieved 17–21 t DM/ha in two long-term studies (Table 2). The yield of 17 t DM/ha was achieved with half the area kikuyu-based and half perennial ryegrass-based pasture. The yield of 21t DM/ha was from an area with all kikuyu-based pasture.

Table 1. Mean annual utilised pasture (kg DM/ha) (grazed and conserved), and pre- and post-grazing pasture cover (kg DM/ha) for the control (C), high stocking rate (HSR), high milk yield per cow (HMY) and high stocking rate and milk yield per cow (HH) systems.

	System					
	C	HSR	HMY	HH	SED	P-value
Stocking rate (cows/ha)	2.5	3.8	2.5	3.8		
Grazed (kg DM/ha)	9,754	11,005	9,458	10,655	483	0.12
Conserved (kg DM/ha)	1,321	99	1,730	561	355	0.06
Total utilised (kg DM/ha)	11,075	11,104	11,187	11,215	754	0.99
Pre-grazing (kg DM/ha)	2,204^{b}	2,084^{c}	2,258^{a}	2,203^{b}	23	<0.05
Post-grazing (kg DM/ha)	1,424^{b}	1,301^{c}	1,492^{a}	1,489^{a}	29	<0.05

^{abc} Values in the same row with different superscripts differ significantly.

Table 2. Mean annual pasture utilised (consumed by the cows by grazing and as conserved forage) at two long-term system studies of FutureDairy.

FutureDairy study	Year 1	Year 2	Year 3	Mean
FutureDairy 1: a system comparison of CFR[1] and pasture (4 pdk/treatment; 50% kikuyu + annual ryegrass 50% of area perennial ryegrass)	17.3	18.0	16.7	17.3
FutureDairy 2: CFS[2] whole farm system (100 cows in 13.5 has of kikuyu-based pasture oversown with annual ryegrass + 8.0 ha of CFR)	23.9	20.8	20.0	21.5

[1]Complementary Forage Rotation; [2]Complementary Forage System

Note: the forage results have been published in the international journal Grass and Forage Science (Garcia et al 2008. The CFS results have been published in the international journal Animal Production Science (Farina et al. 2011).

Tailor to your situation

This tech note gives you the principles and a step-by-step guide to achieve highest possible pasture utilisation levels. These are the ones FutureDairy has used for whole systems experiments with demonstrated success. However, if you want to achieve the highest possible pasture utilisation level on your farm, consider these steps within the context of YOUR system and YOUR goals. The key factors that influence the way the above principles and steps are applied on your individual farm are:

- Region and pasture types.
- Herd size and production system.
- Infrastructure.
- Cow time and genetic merit.
- Other requirements.

Region/area and pasture types: For example, you may be farming in a more complex environment in relation to the number of species and pasture types. The principles are the same, but the application may need to be tailored better.

Herd size and production system: It can be easier to control small herds than large herds. For example, controlling a herd's pasture intake by the time of grazing or amount of supplement fed is easier with small herds. Large herds require larger daily grazing areas and have to walk longer distances.

Infrastructure: Managing supplementary feed to control pasture intake and avoid under or overgrazing may require more infrastructure than you currently have. For example, you may need a concrete-based feedpad or troughs to feed fodder or a mix of supplementary feeds. Or, if you plan to feed in the paddock, you must have good laneways and equipment to ensure the system is sustainable.

Cow type and genetic merit: While the principles apply to all cow types, the application may require adjustments. For example, large, Holstein cows of high genetic merit for production may be underfed if you manage supplements mainly to control pasture intake. Our cows in one of the whole system studies were fed with only 1 kg of concentrate/cow per day over the spring time and, while general efficiency increased, the cows lost too much body weight for a short period of time. This can have adverse effects on reproduction, health and welfare.

Other requirements: For simplicity we emphasised the need to produce and utilise more pasture. However, pastures need to be well established before they can be managed and they also need to be properly looked after over their entire lifetime. Aspects related to pasture establishment and maintenance (e.g. cultivation, weed and pest control, contractors, etc) are not covered here but need to be fully considered on each individual farm.

Final remarks

Key principles behind good pasture management are the same and apply to any and all types of systems, provided enough demand for pasture exists to achieve higher levels of pasture utilisation. Putting these principles into practice is more challenging and requires adequate management of inputs and grazing. This tech note is a guide to help you achieve significant improvements in total pasture utilisation, a key driver of farm profitability.

More information

Contact Associate Professor Sergio (Yani) Garcia
ph 02 9351 1621 or sergio.garcia@sydney.edu.au

References

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

- Complementary forage system tech note series (www.future.dairy.com.au).
- Farina SR, Garcia SC, Fulkerson WJ, Barchia IM (2011) Pasture based dairy farm systems increasing milk production through stocking rate or milk yield per cow: pasture and animal responses. Grass and Forage Science (in press).
- Farina SR, Garcia SC, Fulkerson WJ (2011) A complementary forage system whole-farm study: forage utilisation and milk production. *Animal Production Science 51*(5) 460–470.
- Garcia SC, Holmes CW (2005) Seasonality of calving in pasture-based dairy systems: its effects on herbage production, utilisation and dry matter intake. *Australian Journal of Experimental Agriculture, 45*: 1–9.
- Garcia SC, Fulkerson WF, Brookes SU (2008) Dry matter production, nutritive value and efficiency of nutrient utilization of a complementary forage rotation compared to a grass pasture system, *Grass and Forage Science, 63*, 284–300.
- Gourley et al (2010): Accounting for Nutrients final report http://www.accounting4nutrients.com.au/projectreports.aspx.
- The Greener Pastures project bulletins:
  Nitrogen for intensively grazed dairy pastures (Bulletin 4815 ISSN 1833-7236) and Managing phosphorus in dairy pastures (Bulletin 4811 ISSN 1833-7236) February 2011. Department of Agriculture and Food, WA, Australia.

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.

Appendix 1 Plant growth

How pasture plants grow new leaves

Plants fix atmospheric carbon as carbon dioxide (CO_2) by a process called gross photosynthesis. But plants need oxygen for all their metabolic functions (maintenance of existing structures and synthesis of new tissue) thus expelling CO_2 to the atmosphere as a result. This process is called respiration.

The net retention of carbon, which is the basis of the plant growth we see, is the balance between these two processes (carbon gained by photosynthesis minus carbon lost by respiration). This is also known as net photosynthesis.

Plant cells use this net carbon gain (net photosynthesis) together with water and nutrients absorbed from the soil to form new tissue (carbohydrates, proteins and lipids). The total amount of new plant formed, the green tissue we see in leaves and stems, is called gross growth.

If grown and not used... it's gone…

During the initial phase of vegetative growth (or regrowth), the amount of carbon fixed by photosynthesis is much larger than the amount of carbon respired by the relative small amount of pasture present. Therefore the amount of dry matter (pasture cover) increases. As the plants get bigger, the amount of carbon fixed by photosynthesis increases exponentially but the loss of carbon by respiration also increases proportionally. In addition, the leaves have a finite life and at some point in time the older leaves will commence to decay and die, increasing total carbon loss.

The balance between the gross growth and the leaves lost by decay is known as net growth. If plants are left undisturbed (e.g. grass plants on an undisturbed roadside), the pasture leaves lost by decay will increase until a point in which similar amounts of plant tissue are grown (gross growth) and lost by decay. In grasses such as perennial ryegrass or kikuyu, this means that for every new leaf that is formed, there is a leaf of similar size that decays and die. When this 'ceiling' point is reached, the net growth is practically zero (all plant gain is neutralised by similar level of plant loss).

This means that all leaves that are live and green at one point, will sooner or later decay and die if not removed by grazing or harvesting!

So if:

- Net growth is the difference between gross growth (the new green leaves we see) and senescence (the decaying material or leaves we normally can't quantify).
- All new green leaves will be lost by decay if not harvested at the right time (i.e. net growth will approach literally zero in this case).

Then:

- If we graze or harvest our pastures before decay becomes significant we will maximise net growth, or the amount of pasture harvested or pasture utilised. As we cannot measure decay in practice (and consequently we cannot measure real gross growth accurately!), the only meaningful concept of 'pasture utilisation' is the amount of pasture actually 'harvested', regardless of how much was actually 'grown' by gross growth.

Measuring pasture

The need to measure is related to the level of pasture utilisation to be achieved. Improvements in perennial pasture utilisation from say, 7–8 to about 12–14 t DM/ha can be achieved through simple changes in pasture management such as avoiding overgrazing. But further improvements will be very difficult to achieve without allocating pasture accurately, which requires monitoring pasture. FutureDairy could not have achieved the relatively high levels of total annual pasture utilisation (about 12 t DM/ha with limited irrigation and about 17–>20 t DM/ha under full irrigation in two separate studies) if we had not measured pasture continuously and systematically.

Pasture utilisation can be measured directly by measuring pasture cover weekly, or by measuring pre- and post-grazing cover daily. The direct methods give both overall and individual paddock figures of pasture utilisation.

Pasture utilisation can also be measured indirectly by back calculation. The indirect method gives only an overall figure of pasture utilisation.

Measuring pasture cover weekly (or regularly): If you measure pasture cover on each paddock systematically (e.g. weekly), you can also easily estimate the weekly pasture growth rate (pasture growth rate) of each paddock. This is calculated as the difference between the values of pasture mass on a given week and the pasture mass on the previous week on each paddock. This method also provides a weekly average of total pasture cover of the farm (in addition to the pasture growth rate calculation).

Measuring pre and post-grazing covers daily (or at least several times per week): This requires measures/estimates of all pre- and post-grazing pasture masses on each paddock of your farm. This method can be more accurate and we use it for research purposes (to have accurate measures of pasture utilisation). But it is impractical on commercial farms.

By back calculation: This is the simplest method of estimating pasture utilisation. It is the difference between total annual energy herd requirements (which can be estimated from the average number, body weight and expected milk production of your cows) and the total annual energy fed as supplementary feed (concentrate, maize silage, purchased hay or silage, etc). The energy value obtained is multiplied by the average energy concentration of pasture (e.g. 10 MJ ME/kg DM) and divided by the area to express it on a per hectare basis. This method can be very useful to indicate the level of pasture utilisation on your farm, but it will not help you to achieve higher pasture utilisation.

Appendix 2 Pasture utilisation

The dairy industry uses many definitions and different interpretations of the term pasture utilisation

FutureDairy defines total pasture utilisation as the net annual amount of pasture dry matter (DM) or 'forage mass' per hectare that is consumed by the animals (either by grazing or as conserved forage).

The proportion of pasture grazed by the cows at any one grazing in relation to the total amount of pasture dry matter present before grazing is just an index of apparent 'harvesting efficiency' at that grazing and should not be confused with 'total pasture utilisation'.

Pasture utilisation is sometimes referred to as the proportion of total pasture harvested (i.e. net growth) in relation to total pasture 'grown' (i.e. gross growth). However, the actual amount of pasture 'grown' cannot be realistically measured on farm (because we cannot measure losses of carbon by senescence). Thus this use of the term is meaningless in practice.

ISSN 1839-7336 (Print)