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Jane Kay[1], John Roche[1], Danny Donaghy[2], and Terry Hughes[3]

[1]DairyNZ, Hamilton, [2]Massey University, Palmerston North, [3]RTA Consultancy, Canterbury

Introduction

A key driver of profitable farm businesses is the ability to balance feed supply and feed demand. This requires the formation of a sound strategic plan, where fundamentals such as comparative stocking rate, environment, animal selection, people capability, and infrastructure need to be considered. Then, the appropriate tactical decisions regarding people, animal and feed management need to be made on a short-term basis, followed by the right daily operational choices (e.g. paddock selection, daily grazing management, supplement amount and type).

There is more need than ever to develop the right plan and make the right feed management decisions on farm to ensure every dollar counts. In a pasture-based system, this requires understanding the value of pasture as a feed for the dairy cow, growing and harvesting as much pasture as possible, decreasing operating expenses, and incorporating supplements into the system only when profitable.

To achieve this requires access to evidence-based information and resources regarding dairy cow nutrition and feed management. These resources need to be applicable to pasture-based systems and easy to understand and implement on farm. The following paper uses independent information to help answer ten of the more frequently asked questions on feed management and nutrition in pasture-based systems.

Frequently asked questions and answers

Pasture management

1. Is rotation length important?

Yes, the correct rotation length is critical to maximise pasture growth and quality.

Notes:

Rotation length for ryegrass pastures should be set based on the time of the year and pasture growth rates, or more specifically, leaf emergence rates (Figure 1). A ryegrass tiller maintains up to 3 live leaves and the emergence of these leaves is dependent on current temperature and moisture. The first leaf is the smallest and contributes 15 – 25% of total growth; the second leaf contributes about 35 – 40%, while the 3rd leaf is the largest and makes up the remaining 40 – 50% of the total growth.

Once the 4th leaf starts to emerge, the 1st leaf will begin to die. Thus in order to maximise plant growth and quality, you should aim to graze between the 2nd and 3rd leaf stage (i.e. when the 2nd and 3rd leaf have fully emerged) or earlier if canopy closure has occurred.

If your rotation length is too fast (i.e. before the 2nd leaf has fully emerged), you will reduce pasture growth and, over time, reduce pasture persistence. If rotation length is too slow (i.e. the 4th leaf has started to emerge), then you reduce pasture quality and pasture utilisation as leaves begin to die.

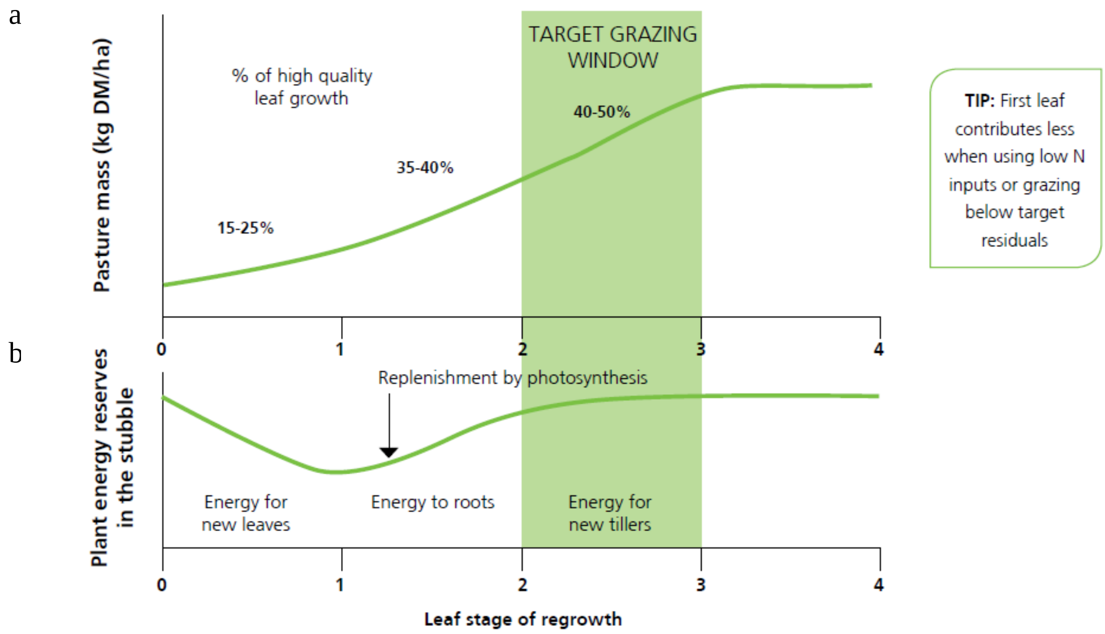

Figure 1. Relationship between leaf stage and a) pasture mass or b) energy partitioning (McCarthy et al., 2015).

2. Does pasture quality affect grazing behaviour?

Yes, if pasture quality is very poor, the increased stem and dead material act as a barrier to grazing, reducing bite size, biting rate, eating time and daily intake.

The cow grazes pasture in successive layers from the top to the bottom of the sward. Increased stem and dead material in poor quality pasture reduces daily DM intake and the energy content of the pasture (Table 1). This results in a decrease in energy intake when pasture quality is low. To maintain good quality pasture throughout the season it is important to focus on the key performance indicators of grazing management, in particular during the spring time.

Grazing pastures between the 2nd and 3rd leaf stage (Figure 1), with pre-grazing yields less than 3200 kg DM/ha and achieving target residuals consistently will maximise leaf (and pseudostem) material in the current and subsequent rounds and ensure there is good quality, high energy pasture available to the cow. In contrast, leaving residuals that are higher than targeted during the spring can result in poor quality pasture in subsequent rounds and reduces whole season performance from pasture (Stakelum and Dillon, 2007).

Table 1. Typical digestibility and ME of plant components (Holmes et al., 2007)

Component	Green leaf	Pseudostem	Hard stem	Dead material
DM digestibility	75-85%	75-80%	40-50%	40-50%
Energy (MJ ME/kg DM)	11–12.5	11-12	6.5	6.5

The value of pasture as a feed

3. Is pasture a good feed for the dairy cow?

Yes, good quality pasture (e.g. ≥ 10 ME and 70% digestible) provides a balanced feed for the dairy cow. It supplies a source of readily available carbohydrates, proteins, lipids, vitamins and minerals.

Typically in a pasture-based system, metabolisable energy (ME) intake is the factor first limiting animal performance and not the nutrient composition of the diet. In this situation, there is no benefit to altering the nutrient composition of the diet (i.e. trying to balance the diet). An increase in production will only occur if energy intake is increased.

A good analogy is a barrel with staves of unequal length. The ability of the barrel to hold water is limited by the shortest stave. It does not matter how much longer the other staves are made, the barrel will still not hold any more water. This is similar to cow performance. For example, if milk production is limited by ME, increasing the protein content of the diet will not increase milk production (Figure 2).

Notes:

In support of this, production from cows being fed a balanced total mixed ration (TMR) was compared with cows grazing pasture during early lactation. A biological model (Cornel Net Carbohydrate and Protein System; CNCPS) was used to determine that approximately 90% of the difference in milk production (44.1 kg vs 29.6 kg milk/cow/day) was due to energy available for milk production (e.g. increased feed availability, greater DM feeds and reduced activity in a TMR system) and only 10% of the difference was due to nutrient composition of the diet (Kolver and Muller, 1998).

Therefore, if cows are eating a diet of good quality pasture, the supply of protein, carbohydrate and fat will be more than adequate to meet requirements, and ME (MJ ME) will be the limiting factor.

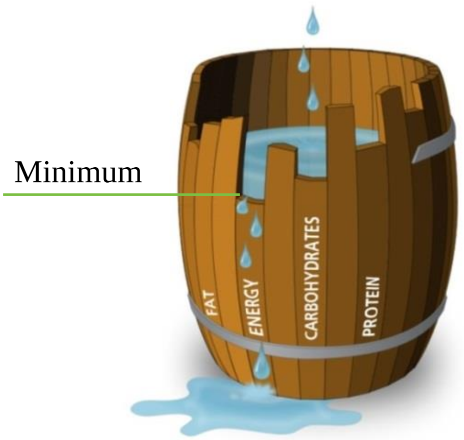

Figure 2. Liebigs law of minimum: increasing the nutrient that is not in shortest supply will not improve performance.

4. Does pasture always provide adequate minerals?

No, at some stages during the season there is a need to supplement a grazing cow with specific minerals.

The dairy cow requires 25 minerals to grow, produce and reproduce; however, many of these are required in such small quantities that they are almost never deficient in the diet. Generally, a pasture-based diet will provide adequate quantities of most minerals; however, at some stages of lactation and in some regions there is a need to supplement a pasture-based diet with some specific macro and micro minerals. Below are nine minerals that may require supplementation in a grazing system; however, it is advised that you speak to a veterinarian about the requirements of specific minerals in your region and on your farm before implementing a supplementation strategy. For more details see review by Roche, 2014.

Macro minerals

Magnesium

Grazing dairy cows should be supplemented with Magnesium (~ 20g/cow/d) from 1 month prior to 4 months post calving, primarily to reduce the risk of milk fever and rye grass staggers.

Calcium

Grazing dairy cows should receive calcium supplementation during the colostrum period to reduce the risk of milk fever. All cows should receive at least 100 g Limeflour per day, with at risk cows receiving 300 g Limeflour per day.

Phosphorus

The use of phosphate fertilisers on many farms means cows grazing pasture are rarely deficit in phosphorus. The exception is cows grazing crops such as fodder beet. Fodder beet is very low in phosphorus and these cows should be supplemented with ~ 50 g Dicalcium Phosphate (DCP) daily while grazing the crop.

Sodium

A deficiency in sodium is rare in pasture-based diets and only generally occurs if large amounts (> 5 kg DM) of maize silage or grain are being fed. In these situations, supplementing with 40 g salt (NaCl)/cow/day is recommended.

Micro minerals

Cobalt

Although the requirements of cobalt (to ensure adequate Vit B12 production) are generally met by pastures, increased levels of cobalt have been shown to increase the digestion of fibrous feeds. Because of this benefit, it is recommended that cows are supplemented with 8 – 10 mg cobalt/day which is equivalent to 40 – 50 mg cobalt sulphate/cow/day.

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Copper

Grazing cows should be supplemented daily with 200 – 300 mg of copper. This is because the copper content of pastures is low, copper absorption from pastures is low, and concentrations of minerals that interfere with copper absorption are often high in pasture. However, it is important to note that copper toxicity can occur, therefore you should account for all sources of copper in the diet (e.g. PKE, water sources, fertiliser) before supplementing with additional copper.

Iodine

An exact recommendation for Iodine supplementation in grazing cows is difficult for several reasons:

- The iodine concentration in pasture varies considerably
- The iodine requirement of the cow varies depending on metabolic state and diet (e.g. brassicas)
- The amount of iodine the cow is already receiving (teat spray etc.) also varies.

Taking these variables into consideration, it is recommended that cows are supplemented with iodine while grazing brassica crops (7 ml of a 5% tincture of iodine sprayed on the flank or rump of the cow) and for 4 months post-calving (10mg iodine/cow/d).

Selenium

The selenium content of pastures is generally low, however the requirement for selenium is difficult to predict. Recommendations are to provide an additional 3-5 mg/day of selenium to grazing cows.

Zinc

Zinc is important for many biological functions and plays an important role in reducing the risk of facial eczema. However the zinc concentration of pasture is very variable and hard to predict. Because of this it is recommended that grazing cows are supplemented with between 500-750 mg zinc per day, but the zinc content of other supplementary feeds needs to be considered.

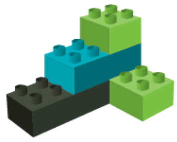
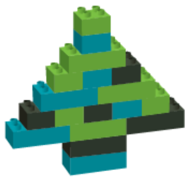
5. Is pasture a good source of carbohydrates?

Yes, the structural carbohydrates (e.g. fibre) in good quality pastures are highly digestible (70-85%) and degraded relatively quickly in the rumen, thereby supplying similar metabolisable energy to non-structural carbohydrates (starches and sugars).

Carbohydrates make up a large proportion of the plant dry matter and provide the major energy source for ruminants. In theory, milk production is optimised when non-structural carbohydrates (soluble sugars and starches) make up ~ 35% of the diet. Although pasture contains less than this, the structural carbohydrates that are found in good quality, leafy pastures are highly digestible and degraded relatively quickly, thus supplying similar ME. In fact, unless the total amount of energy supplied in the diet is increased, replacing structural carbohydrates (e.g. pasture) with non-structural carbohydrates (e.g. starch) does not improve the energy generated from microbial fermentation.

This is because these carbohydrates are all made up of the same simple sugar units and the only difference is the bonds that join these sugar units together. If you think of carbohydrates as being Lego blocks, then soluble sugars, found in feeds such as molasses, are like a pile of Lego blocks, pulled apart and ready to be used by the rumen bugs straight away (Table 2).

Table 2. Carbohydrate types and characteristics

Type of Carbohydrate	Commonly called	Characteristics	Example
Non-structural	Sugar	Individual sugars within the plant cell Found in leaves of plants Rapidly digested and used by microbes	 Lego bricks loose and ready to be used
Non-structural	Starch	Sugar sub-units joined together within the plant cell Found in grains, leaves, and plant stems and bulbs Digested more slowly than sugars but faster than structural carbohydrates	 Lego bricks simply joined together, need to be pulled apart before can be used
Structural	Fibre (Hemicellulose and cellulose)	Fibrous component of the plant cell wall Provide structural support for the plant In high quality pasture digested at a similar rate to starch	 Lego bricks joined together in a complex way that requires more time to be broken down

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In comparison, starch, found in cereal grains or vegetable wastes, is like having the same Lego blocks but joined together, and these need to be pulled apart before they can be used. Finally, structural carbohydrates, found in good quality pastures, are similar to a complex object made from the same Lego blocks, which takes time to pull apart before they can be used. Luckily, the rumen bugs are capable of breaking all these bonds (or pulling the Lego constructions apart) so they can use the sugar molecules for energy.

However, if pasture quality is low, digestibility of the carbohydrates decreases and ME is reduced (Table 1). This is partly due to the increase in lignin as the plant matures and the amount of hard stem increases. Lignin is indigestible and although it is not a carbohydrate, it can bind to the structural carbohydrates (cellulose and hemicellulose) and make them less digestible in the rumen (like having the Lego blocks stuck together with super glue!!). Therefore minimising the amount of lignin in the pasture through good grazing management is important for the performance of the dairy cow.

6. Does carbohydrate type alter milk production?

Yes and no. Yes, milk components (protein and fat) are altered, but no, there is no impact on total milksolids' yield, unless the total energy of the diet is changed.

Generally, feeds high in structural carbohydrates (e.g. pasture, silage, soyhulls, PKE) will produce more milk fat, while feeds that are high in non-structural carbohydrates (maize grain, barley, wheat) will produce more milk protein (Figure 3). If energy of the diet remains the same, there is no change to the total amount of milksolids that is produced.

Figure 3. Change in milk fat and protein yield when carbohydrate composition of the diet was changed but energy remained the same (Roche et al., 2010).

7. Is there enough fibre in pasture?

Yes, there is adequate fibre in pasture (even spring pasture) for the rumen to function properly.

Sometimes the appearance of loose or runny dung is taken to indicate that the cow has a rumen upset or is suffering acidosis. Unless there are other health issues present, this is not the cause in cows grazing pastures. Loose or runny dung in grazing cows is generally due to the low DM % of the pastures (especially during spring). The extra water that is consumed when the pasture is eaten cannot be absorbed and passes through the digestive tract, resulting in watery, loose dung.

It is sometimes recommended that cows grazing spring pasture require extra fibre; however, in several research experiments, where cows were grazing spring pasture and in some supplemented with 5 kg DM/cow/ day of cereal grain, there was no benefit to rumen function or milk production when additional fibre (straw/hay) was added to the diet (Wales and Doyle, 2003).

8. Does a grazing dairy cow require supplementary protein?

No, when cows are fed a diet high in good quality pasture, there is no need for additional protein.

Metabolisable protein in the dairy cow comes from two sources, either directly from the diet (e.g. dietary protein that passes through the rumen undegraded; undegradable dietary protein/by-pass protein) or, indirectly, from microbial protein.

Microbial protein is produced when the rumen microbes use dietary protein that is degraded in the rumen for their own growth. The microbes are then flushed through the rumen, into the small intestine, where they are degraded themselves to provide protein for the dairy cow.

The rumen microbes can also use nitrogen sources (non-protein nitrogen) such as urea, to form microbial protein; however there is a limit to the amount of microbial protein that can be produced. In grazing cows, particularly in spring there is already adequate protein degraded in the rumen and therefore ***supplementing cows that are grazing good quality pasture with a source of non-protein nitrogen (e.g. urea) will not improve protein availability or production.***

Additionally, although 70-90% of the protein in pasture is degradable in the rumen, the fast rumen passage rate (particularly in spring) means that some of the degradable protein actually flows through to the small intestine undegraded. Combined with the high crude protein

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content of pasture, this means there is more than enough by-pass protein to meet requirements. Therefore, ***supplementing cows that are grazing a diet of good quality pasture with by-pass protein will not improve protein production or milk yield***.

Feeding supplements

9. How do I determine the milksolids response to supplements?

The milksolids response to supplements depends on several key factors including supplement management, how hungry the cow is, and where the energy is partitioned to.

When supplements are incorporated into a pasture-based system, there is the potential for total intake and production to increase, however the actual milksolids response is variable and often less than expected. This is because there are several key factors that affect the milksoilds response to supplements (Figure 4).

The total milksolids response from the supplement is the sum of the immediate milksolids response (extra milksolids produced while the cows are receiving the supplement), plus the deferred milksolids response (extra milksolids produced due to pasture spared/grown and body condition gained while the supplements were being fed).

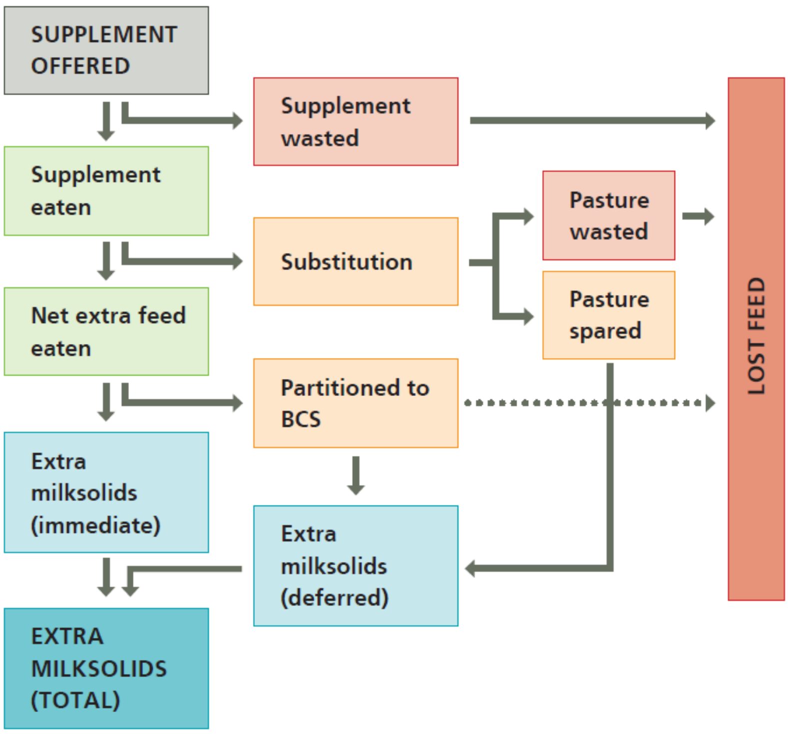

Figure 4. Key factors that affect the total milksolids response to supplementary feeds in a pasture-based system (Holmes and Roche, 2007).

From a physiological perspective, the dairy cow requires approximately 75-85 MJ ME to produce 1 kg milksolids (3.5% protein and 4.5% fat). Therefore, energetics would predict that 1 kg DM (~11 MJ ME) could produce 140-150 g MS; however, this is the maximum possible physiological response and assumes that all the ME from the supplementary feed is converted into milksolids which is not the case in a grazing situation.

Wastage

When supplementary feeds are offered to grazing cows, even with best practice management, there will be some wastage. Wastage occurs both during the transporting and feeding out process, and while the cows are eating the supplementary feeds. The amount of wastage varies depending on the feed, feeding method, infrastructure and care taken by the operator. Good rules of thumb for wastage are:

- 5% for in-shed feeding
- 10% for feed offered on a feed pad
- 15% for feed offered in trailers in the paddock
- 20% for feed fed out in the paddock in good (dry) conditions
- 40% for feed fed out in the paddock in poor (wet) conditions.

Substitution

Typically, the factor that has the greatest impact on the milksolids response is the reduction in pasture intake when supplementary feeds are eaten; this is known as substitution. There is always some substitution when grazing cows eat supplementary feeds, and on average, cows will graze for 12 mins less for every 1 kg DM of supplementary feed that is eaten. What is important to remember is that substitution can be positive or negative depending on how pasture is managed (Figure 5).

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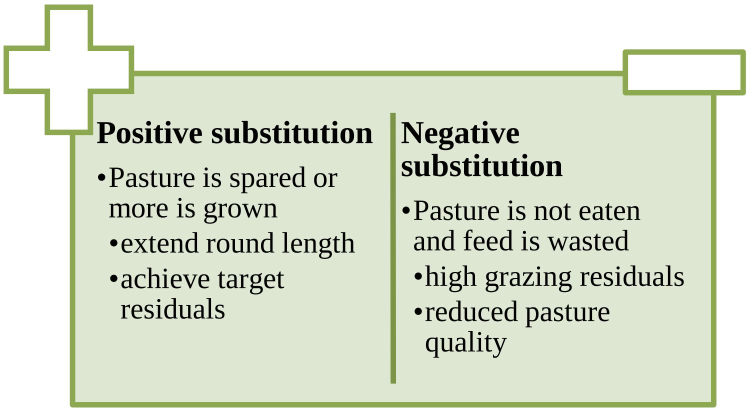

Figure 5. Positive and negative substitution

If good quality, high energy pasture is left behind in the paddock and not eaten, this is negative substitution, as feed (energy) is lost, hence the phrase “use it or lose it”. In addition if pasture residuals are not corrected, pasture quality will decrease in the next round. In contrast, if extra pasture is grown due to the use of supplements (e.g. extending the rotation or achieving target residuals) this is positive substitution. The additional pasture grown will be eaten at a later date and will contribute to the deferred milksolids response.

Although substitution always exists, the rate of substitution can vary and is influenced by many feed and animal factors (Stockdale, 2000):

Pasture residuals

One of the main determinants of substitution is how hungry the cow is and this is generally reflected in the grazing residuals. The hungrier the cow is, the lower the residuals, the lower the substitution rate and consequently the greater the milksolids response.

Pasture type and quality

At a given level of pasture intake there is a greater level of substitution when the pasture consists of grass dominant species compared with clover dominant species.

Within the same species of pasture, the greater the pasture quality (digestibility), the greater the rate of substitution when supplements are fed.

Supplement intake

As the amount of supplementary feed eaten increases, the level of substitution increases, primarily due to the fact that the cow is not as hungry (satiety signals are sent to the brain of the cow) and she is not prepared to spend extra energy harvesting pasture.

Supplement type and quality

Substitution is about 10% greater with a forage (e.g. cereal silage) compared with a concentrate (e.g. cereal grain), and is greater with highly digestible concentrates (e.g. cereal grains) compared with protein-based supplements.

Substitution is greater with starch-based compared with fibre-based concentrates, most probably due to the greater production of satiety signals and hormones (e.g. insulin) from these feeds.

Cow body condition score and genetics

Cow factors such as body condition score (BCS), which reflects energy state or production level can affect the rate of substitution. If offered the same amount of supplementary feed, a cow with a lower body condition score will have a lower level of substitution, compared with a cow of greater body condition score. This is because she will have a greater drive to eat.

Higher producing cows tend to have a lower substitution with supplementary feeds and thus have a greater milksolids response. The greater response is predominantly due to differences in the immediate milk response, as these cows will partition more energy to milk production at the expense of body reserves. However, it must be noted that these cows generally require more feed later in the season to gain body condition, so the whole season total milksolids response is not as great as first thought.

Season

Substitution is greatest in spring and lowest in autumn. For every kg DM supplementary feed offered, substitution is 0.1 kg DM greater in spring than in summer, and 0.1 kg DM greater in summer than autumn.

For example if the substitution rate was 50% in spring (i.e. for every 1 kg DM supplement eaten, 0.5 kg DM pasture was left behind), in summer, substitution rate would be 40% (0.4 kg DM left behind) and in autumn 30% (0.3 kg DM pasture not eaten). This is often referred to as pasture having a longer shelf life in autumn, compared with spring.

Notes:

Energy partitioning

In early lactation, cows are genetically predisposed to produce milk. Thus, the majority of the extra energy eaten when supplements are fed, is partitioned to milk production. However, as the season progresses, more of the energy is partitioned towards body condition score. The partitioning of energy (between milk production and body reserves) depends on several factors including:

- Energy status of the cow – more energy is partitioned to body reserves in thinner cows
- Genetics of the cow – more energy is partitioned to body reserves in lower producing cows
- Amount of supplement fed – more energy is partitioned to body reserves as the amount of supplement increases.

The energy that is partitioned towards BCS is taken into account through the deferred milksolids response; however, the amount of ME produced when body reserves are mobilised is less than the energy used to store these. This is because some energy is lost during the storage of BCS (Figure 4).

In summary, the total milksolids response depends on many variables and these all need to be considered, in addition to the cost of feeding the supplement (see question 10) when determining the amount of supplement to include in a system and how to best manage the supplements and pasture on a daily basis (Figure 6).

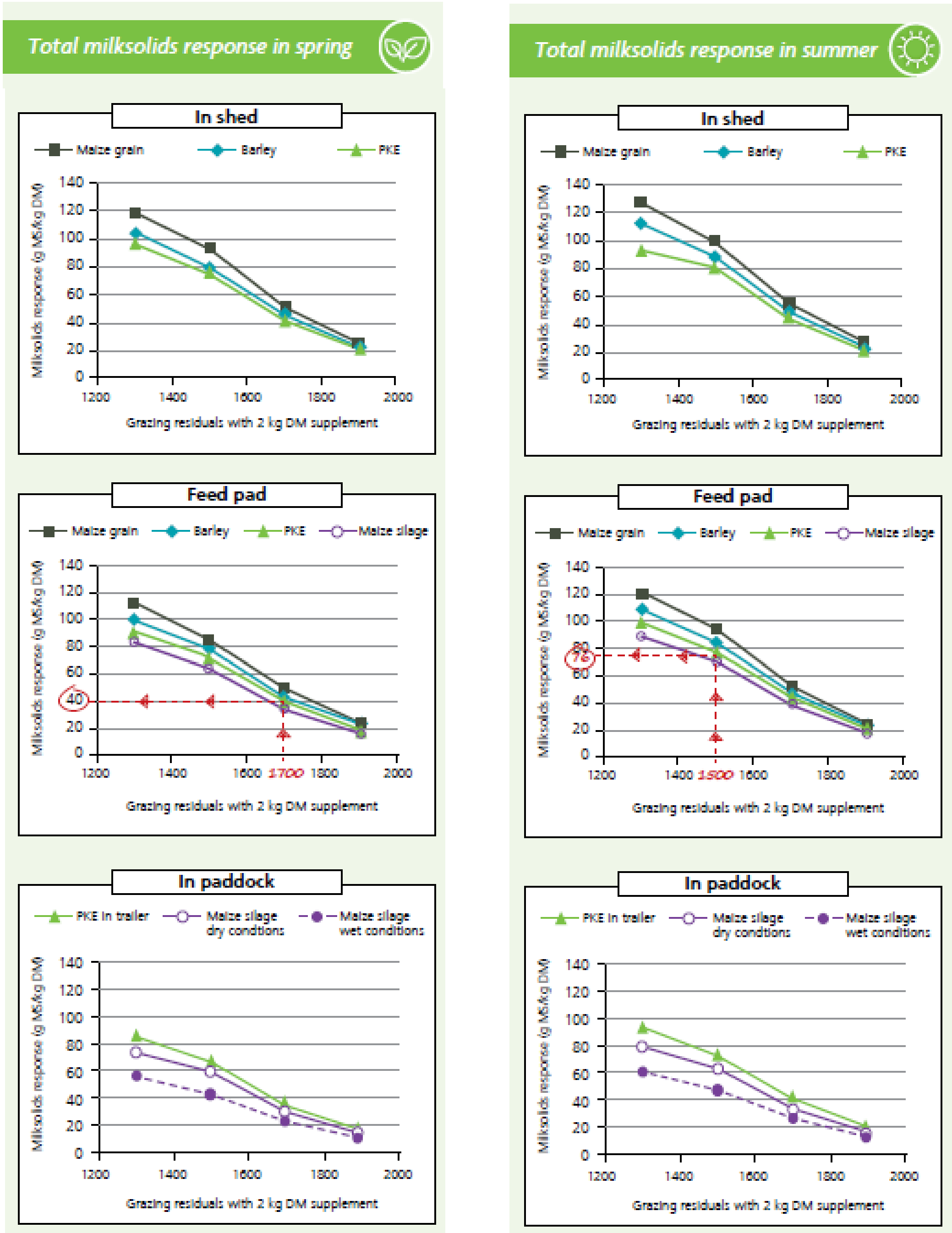

Figure 6. Estimated milksolids response to some commonly fed supplements using different feeding methods at varying residuals. The red arrows represent the estimated milksolids response in spring (40 g MS/kg DM) for a cow eating 2 kg DM PKE on a feed pad and leaving

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residuals of 1700 kg DM/ha and in summer (76 g MS/kg DM) for a cow eating 2 kg PKE on a feed pad and leaving residuals of 1500 kg DM/ha (DairyNZ Spring and Summer Feeding Checks; http://www.dairynz.co.nz/publications/feed/).

10. How do I determine the cost of feeding supplements?

The total cost of feeding supplements needs to include the cost of purchasing the supplementary feed plus any associated and non-associated costs that increase when supplements are introduced into the system.

It is not accurate to simply use "Margin over Feed" as a way of accounting for the cost of inputting a supplementary feed. This assumes that the only cost of feeding is that of the feed itself and ignores associated costs such as fuel/energy, repairs and maintenance, and labour. These associated costs generally equate to between 10 - 20% of the actual cost of the feed. For example, the DairyNZ Supplementary Price Calculator estimates an additional cost of feeding supplement of 2.7 c/kg DM for in-shed feeding, 3.0 c/kg DM for feeding palm kernel expeller (PKE) in a trailer in the paddock, 4.5 c/kg DM for feeding silage on a feed pad, and 5.7 c/kg DM for silage fed in the paddock.

Interestingly, analyses of large datasets has identified that in addition to an increase in the associated costs, there was an increase in all costs on the farm when supplements were introduced into the system. Analyses of a National database in 2012 (DairyCo, 2013) highlighted an increase in total farm costs of £1.62 for every £1 spent on imported feeds (i.e. forages and concentrate feeds) and an analysis of four years of data from more than 2,700 farms in Ireland highlighted that, on average, the total cost of production increased €1.52 for every €1 spent on purchased feed (Ramsbottom et al., 2015).

Therefore, total costs in these systems, increased by 50-60% more than the feed cost itself, when additional feed was fed. These analyses were conducted in the UK and Ireland and robust analyses of New Zealand data are required to determine what the true cost is of feeding supplements for New Zealand dairy farmers. However, there needs to be some allowance made for the increase in all costs (variable and fixed) when supplementary feeds are incorporated into a grazing system (Kay et al., 2014).

Summary

Understanding feed management and nutrition in a pasture-based system, and being able to make informed decisions with regards to pasture management and the use of supplementary feeds, are vital for a successful farm business.

The resources highlighted, and the answers provided in this paper to ten of the frequently asked questions, will help ensure feed management decisions that are made on farm are profitable and sustainable.

References

DairyCo Milkbench Report. 2013. http://www.dairyco.org.uk/resources-library/technical-information/milkbenchplus/milkbenchplus-report-2013/

DairyNZ Supplementary Price Calculator: http://www.dairynz.co.nz/feed/feed-management-tools/supplement-price-calculator/

Holmes C W, I M Brookes, D J Garrick, D D S Mackenzie, T J Parkinson and G F Wilson. 2007. Milk Production from Pasture. Massey University, New Zealand.

Holmes C W, and J R Roche. 2007. Pastures and supplements in dairy production systems. Pages 221 – 242 in Pastures and Supplements for Grazing Animals. P V Ratray, J M Brooks, and A M Nicol, ed. New Zealand Society of Animal Production, New Zealand.

Kay J K, S McCarthy and J R Roche. 2014. Supplement use and making money – the devil is in the detail. Proceedings of SIDE: 3.2

Kolver E S, and L D Muller. 1998. Performance and nutrient intake of high producing Holstein cows consuming pasture or a total mixed ration. Journal of Dairy Science. 81: 1403 – 1411.

McCarthy S, C Wims, J Lee and D Donaghy. 2015. Perennial ryegrass grazing management in spring: A paddock guide. http://www.dairynz.co.nz/publications/feed/

Ramsbottom G, B. Horan, J R Roche and D.P. Berry. 2015. Factors associated with the financial performance of spring-calving pasture-based dairy farms. Journal of Dairy Science 98: 3526 – 3540.

Roche J R. 2014. Mineral supplements – the KISS principle. Proceedings of SIDE 2014: 5.4.

Roche J R, J K Kay, C V C Phyn, S Meier, J Lee and C R Burke. 2010. Dietary structural to non-structural carbohydrate concentration during the transition period in grazing dairy cows. Journal of Dairy Science. 93:3671 – 3683.

Stakelum G and P Dillon. 2007. The effect of herbage mass and allowance on herbage intake, diet composition and ingestive behaviour of dairy cows Irish Journal of Agricultural and Food Research. 43: 17 – 30.

Stockdale C R. 2000. Levels of pasture substitution when concentrates are fed to grazing dairy cows in northern Victoria. Australian Journal of Experimental Agriculture 40:913 – 921.

Notes:

Wales W J and P T Doyle. 2003. Effect of grain and straw supplementation on marginal milk production response and rumen fermentation of cows grazing highly digestible subterranean clover pasture. Australian Journal of Experimental Agriculture. 43:467-474.