INCORPORATING GRAIN INTO THE SYSTEM

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Outline

- Pasture eaten per hectare is closely related to dairy farm profitability. This principle applies to all farms.
- In contrast, no relationship between supplement fed, either per hectare or per cow, and profit can be seen when data for NZ dairy farms are analysed.
- Debates about the merits or otherwise of using grain are often confused with the issue of whether or not to use supplements. These are different, though related, questions.
- A positive relationship between supplement use and profit is most likely to occur when the supplement fills genuine feed (energy) deficits created by pasture shortage.
- Feeding supplements in such circumstances reduces risks of overgrazing (below 1500 – 1600 kg DM/ha, or 7-8 clicks on the rising plate meter) and/or grazing too early in the regrowth cycle and helps maximise pasture eaten.
- If supplement is used when pasture supply is adequate for herd requirements, pasture will be wasted, and profit will be reduced.
- Grain is one of several types of energy supplement available. Others include PKE, maize silage, cereal silage, and good quality pasture silage.
- Like any other supplement, decisions about grain feeding should be based on the extent to which this feed can help increase pasture eaten within your farm system.
- Decisions about grain feeding should also take into account how grain differs from other supplements, and if those differences are likely to yield an advantage in your farm system.
- Calculating the margin between income from extra milksolids per unit feed offered and the price paid for the feed underestimates true costs and overestimates profit. A full analysis of return on assets or return on capital is recommended to support decisions regarding a major change like introducing supplements into the farm system.
- Feeding grain is a good decision ***if*** it is based on the key principle of using supplements to increase pasture eaten, and is consistent with the goals of the farm business.

Grain in perspective

Feeds used on dairy farms in NZ can be broadly categorised as shown in Table 1. All NZ dairy farms use pasture on the milking platform. However, usage of the other feeds varies greatly between farms depending on resources available to each farm business and the type of system that works best for each farm owner/operator. The term ‘supplements’ generally refers to feeds that are not harvested directly by the cows: that is, columns 3 and 4 in Table 1.

Table 1. Feeds for dairy cows: examples

1. Pasture grown and grazed on the milking platform or support land	**2. Crops grown and grazed on the milking platform or support land**	**3. Feed grown and conserved on the milking platform or support land**	**4. Feed purchased from off farm**
Grass Clover	Kale Rape Turnips Swedes Fodder beet Cereals eg greenfeed oats Herbs eg chicory, plantain	Pasture silage Maize silage Cereal silage Hay	Pasture silage Maize silage Cereal silage Hay Grain (mainly barley, wheat) PKE By-products Straw

DairyNZ has identified five broad types of farming system in NZ, which differ in the amounts of supplement used when expressed as a percentage of the total feed consumed on the farm per year. These are shown in Table 2. Supplementary feed use has increased substantially on New Zealand dairy farms over the past 2 decades. In Canterbury, over 90% of farms are using supplements to extend lactation in autumn or spring, to feed cows all year round, and/or during the winter period (systems 3-5, Table 2). This is well above the national trend for the proportion of farms operating systems 3-5. The equivalent figure in Otago-Southland is around 60%, similar to the national trend.

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Table 2. Distribution of owner-operator dairy businesses according to production system 1 – 5 in 2008-09. Source: DairyBase, DairyNZ Economics Group, November 2010. Systems 2-4 use supplements mainly to extend lactation

	NZ	**Waikato**	**Lower NI**	**Canterbury**	**Otago-Southland**
Total farms in DairyBase	508	170	40	65	44
% farms in each system:					
1 (no supplement used))	10	8	8	2	14
2 (~ 4-14% of total feed)	27	26	15	5	25
3 (~ 10-20% of total feed)	39	42	50	37	41
4 (~20-30% total feed)	19	18	23	48	11
5 (~25-40%, used all year)	6	6	5	9	9

Despite the now-widespread use of supplements (or, perhaps, because of it?), farmers often express confusion and frustration with information surrounding supplementary feeding and how to apply it to their farm business. Grain appears to attract more discussion in Canterbury than any other form of supplement. The words “any other form of supplement” are important: while it will not remove the confusion totally, it may be helpful to see grain from the perspective that it is one of several types of supplement, and work back from the principles of successful supplement use.

Grain appears in column 4 of Table 1 as an example of a purchased feed that can be used to bridge shortfalls in feed supply. All the feeds in column 4 are energy supplements: they bring extra energy into the cow’s diet to meet total energy demand. The first point to be clear about, then, is that grain is one of several options for supplementary feeding. It differs in several respects from other forms of purchased supplements, as we shall discuss below. But these differences are not so great as to warrant putting grain in a feed category all on its own. The principles of successful supplementary feeding apply equally to grain as to other forms of purchased supplement. Often arguments about the merits or otherwise of using *grain* are, in fact, arguments about the merits or otherwise of *supplementary feeding*. These are issues are related, but also different. It is important to be clear about when and why grain might work better or worse than other supplements, and not to confuse this with whether or not supplements, in general, are appropriate for a given situation.

How does grain differ from other supplements? There are a few clear distinctions:

1. It is almost always purchased from off-farm and is, therefore, subject to the normal trading fluctuations in availability and price associated with commodities. Supplements that are

grown on the farm, such as pasture silage, are not subject to these fluctuations and, therefore, the costs of supplying these feeds are more predictable. We note, however, that variability in the cost of grain to the farm business can be reduced by practices such as purchasing on forward contracts.

2. It tends to be more expensive than other purchased supplements per tonne of dry matter (but may not be more expensive if compared in terms of total energy – see below)
3. It can be fed relatively easily and conveniently in the shed, while cows are being milked (provided suitable feeding equipment is installed), whereas others like conserved forages require a feed pad or are fed in the paddock which adds a labour cost and can lead to high losses
4. It tends to have a greater energy density, measured in megajoules (MJ) of metabolizable energy (ME) per kilogram of dry matter (DM), than other feeds. This is why grain is often referred to as a 'concentrate' feed.
5. Animals need a period of adaptation to grain in their diet to avoid health risks such as rumen acidosis, whereas most other supplements are generally safe in this regard. We note, however, that some home-grown feeds such as fodder beet, turnips and swedes also require a transition period when the feed is introduced gradually into the diet to avoid metabolic problems so grain is not totally alone in this regard.

In this paper, we propose that the use of energy supplements should be firmly anchored to:

1. the principles of efficient pasture use, and the implementation of practices that maximise pasture harvest
2. the principles that lead to efficient conversion of feed offered to milk
3. clear understanding of the strengths and weaknesses of different approaches to estimating the costs of, and returns from, supplementary feeding; and very importantly
4. the goals of the farm business.

There will be instances where supplements are fed because they help achieve the goals of the farm business, in which case the efficiency principles in 1) – 3) carry less weight; for example if profit is not the dominant goal. Where profit is the dominant goal, or a dominant

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goal, then the efficiency principles 1) – 3) are more important than 4). We will revisit the list of distinct features of grain, above, after considering these principles.

Basic principles: pasture harvest

Despite the trend toward greater use of supplements (Table 2), NZ dairy systems remain pasture-based. The positive relationship between profit and the amount of pasture harvested per hectare is just as strong today as it was when the industry started to intensify in the 1950's. The principles that underpin high pasture harvest rates in our pasture-based systems have been well and truly established over the past 6 decades of research and farmer innovation. These can be boiled down to:

- Matching seasonal feed demand of the herd to seasonal supply of feed from pasture as closely as possible throughout the annual cycle, through appropriate choice of stocking rate and calving date
- Timing the grazing of regrowth to hit the point when the regrowth rate of pasture since the last grazing is about maximum, and accumulation of dead leaf (wastage) is minimal;
- Maintaining close control over pasture residuals, such that pasture regrowth rate and quality is consistently close to the maximum possible for the environmental conditions that prevail; and
- Maintaining the supply of soil nutrients needed to support high growth rates, while controlling the incidence of pests and weeds that restrict growth.

The first bullet point covers the big-ticket strategic decisions that determine how the farm system operates. These decisions are usually re-visited infrequently, eg. every few years. The other bullet points are examples of tactical decisions: they are made quite frequently, often daily, and they are what keep the system tracking well with respect to production, costs, etc as each season unfolds. Rotation length, feed wedges, N fertiliser and areas allocated to the herd are all levers that help keep pasture and animal production ticking along in spite of better-than or worse-than expected pasture growth, season by season.

So where do supplements fit within this mix of strategic and tactical decisions? Firstly, if feed demand exceeds feed supply from pasture alone, then extra feed energy will be needed for production and to ensure cow body condition score and pasture cover are not pushed beyond sustainable limits. However, <u>supplementary feeding may not be the most cost-effective response to this situation, if it occurs for prolonged periods</u>: for example it may be better to reduce feed demand in some way, such a lowering stocking rate or decreasing milking frequency.

Secondly, supplements can be used to help manage pasture residuals and to ensure grazing occurs at the ideal point during each regrowth cycle. It is often assumed that there is a very long lag phase at the start of regrowth coinciding with emergence of the first new leaf on ryegrass tillers, followed by very rapid regrowth as the second and third leaves emerge later in regrowth. This is certainly the case when very little leaf area remains after defoliation. However, when pastures are consistently grazed to a uniform residual of 7-8 clicks on the plate meter (1500 – 1600 kg DM/ha), the ryegrass plants in the pasture adapt so that some leaf area is retained below grazing height and the lag phase is not as pronounced. Typical patterns of regrowth in pastures managed this way are shown in Figure 1.

Note, however, that the lag phase is still present in most of the regrowth curves in Figure 1, hence it is still best to graze at closer to 3 leaves than 2 leaves because there is an increase in average growth rate right up to the point when the third leaf has fully expanded. The dry matter added to the pasture by the third leaf is approximately 10-15% greater than the amount added by the second leaf (Chapman et al. unpublished data). This is valuable additional feed which should always be captured as pasture eaten. ***Adding supplements can help extend the round length so that all of the regrowth potential can be captured in feed down the cow's throat.***

Often, short-term changes in pasture growth rate and feed demand make it difficult to implement perfect control over the timing of grazing of each paddock on the farm on every occasion. In these situations, flexibility is needed to cope with changing circumstances. ***So long as consistent post-grazing residuals of around 1500 – 1600 kg DM/ha are maintained***, there is good flexibility in the system to respond to short-term changes without incurring very large losses in pasture harvest. ***Adding supplements to make up the difference between pasture feed available and total herd feed demand can prevent over-grazing of pastures*** and offer flexibility to manipulate round length if required. Grazing to less than 1500 – 1600 kg DM/ha will push regrowth further into a lag phase, slow pasture growth, and decrease total farm cover (because pasture mass at three leaves will be less than the mass at three leaves if residual was 1500 – 1600 kg DM/ha).

Farmers should have confidence that well-managed residuals will lead to robust pastures and high pasture harvest rates. This is a sound reason to use supplements if there is a risk of pastures being grazed below 1500 -1600 kg DM/ha. The value of using supplements in this case is probably higher than the value gained from extending round length. An exception here is if

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grazing is occurring at 2 leaves or less, in which case the round length is too short, and pasture eaten is not being maximised.

A final consequence of maintaining good control of pasture residuals is that changes in the ME and protein content of the pasture during regrowth will be consistent. Therefore, we can predict reasonably accurately how much energy and protein the cows will consume for a given amount of pasture eaten. This gets us to 'first base' for deciding whether or not supplements are needed to sustain production and, if so, how much supplement to feed.

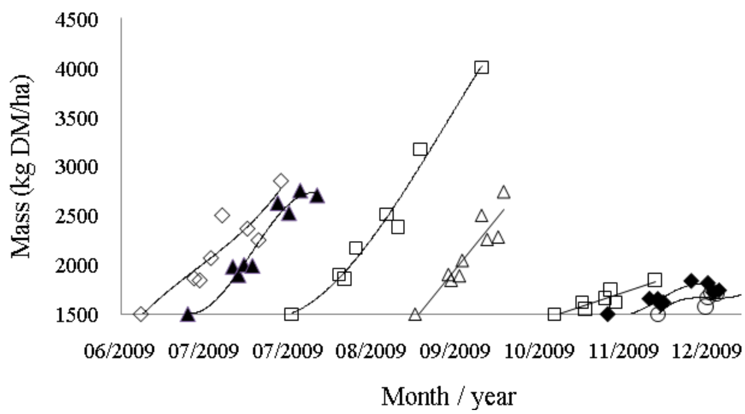

Figure 1. Examples of regrowth curves for perennial ryegrass pasture, from south-west Victoria, Australia (Chapman et al., unpublished data). Slow regrowth at the end of the year was due to the onset of very dry summer conditions

Summary of key practices

- Set the stocking rate so that feed supply and demand are in balance over an annual cycle. Have cost-effective strategies available for dealing with imbalances that occur between seasons and years. Supplements can play an important role here.
- Leave 1500 – 1600 kg DM/ha (7-8 clicks on the plate meter) after grazing ***consistently***. This will lead to predictable regrowth rates and pasture nutritive value, making feed and pasture management a lot easier.
- ***Add supplements if necessary to help achieve the target residuals***. This can be a good reason to use supplements because it shores up the major driver of profit on dairy farms, namely total pasture harvest per hectare

Basic principles: feed conversion efficiency

The efficiency with which feed is converted to milk can be estimated by calculating the milksolids produced per unit of feed offered, that is g MS/kg feed, or g MS/MJ of ME. The higher the number we get from this calculation, the more efficient the feeding and the better the economic return from money spent on feed. In the case of supplements, the milk response from the additional feed will depend on several things. These include:

- the energy density (MJ ME/kg DM) of the supplement
- how much supplement is offered
- at what stage of lactation the supplements are being used
- genetic merit of the animal
- how much of the supplement is wasted, and
- the amount of pasture intake that is substituted by supplement intake, and how much of the substituted pasture is lost to the system.

Substitution is a form of wastage since pasture not eaten usually ends up dying and decaying. When substitution is high and the energy content of the supplement and the pasture is similar, there will be little net gain in energy intake or in milk production: only wastage of feed.

The 'big ticket' item governing milk response to supplements in NZ pasture-based systems is the size of the energy deficit that the cows are experiencing when the supplement is offered. This directly influences the level of substitution, which is a critical in determining response. Short-term milk production responses to supplement feeding on pasture have been reviewed by Holmes and Roche (2007). The theoretical maximum production response is 130 – 140 g MS/kg supplement offered, but most reported research trial response have been lower than this, and average responses on-farm are lower still. When pasture intake is restricted below the level needed to meet energy demands, responses in the range 80 – 100 g MS per kg grain have been recorded in NZ trials (McCullum et al. 1994, Penno et al., 1999). In the Penno et al. (1999) experiment (conducted over three years), cows were either fed pasture only or fed grain when pasture did not meet energy demand. MS production averaged 1188 and 1711 kg/ha per year for the respective treatments. Days in milk were extended to 284 for the grain-fed animals versus 217 for the un-supplemented animals. Pasture substitution rate for the grain-fed group was low at 16% (i.e pasture intake per cow decreased 0.16 kg DM for every 1.0 kg grain offered). This resulted in higher total intake for this group, 5.3 t DM/cow, versus 4.2 t DM/cow for the un-supplemented group.

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By contrast, Kolver et al. (2005) offered cows grain when pasture was in excess of demand. Pasture residuals were maintained at 1800 kg DM/ha in spring and autumn and 2200 kg DM/ha in summer using silage if required. Additional grain was fed at a flat rate of 3 kg or 6 kg/cow per day. They reported responses of 66 g MS/kg grain when 3 kg of grain was fed and only 29 g MS/kg grain when 6 kg was fed. These results show that the efficiency of feeding decreased as more supplement was offered, because animals simply substituted the higher intake of supplement for pasture. Substitution climbed to over 70% at the high feeding rate, implying considerable wastage of grass. This is an expensive waste when the fixed costs of owning land are considered, as well as the variable costs of growing the pasture in the first place.

Furthermore, if not all the grass available is eaten at any grazing event, the residual will increase which implies that the paddock should be re-grazed earlier than normal to prevent excessive leaf death and loss of quality. If this does not happen (or if the paddock is not cut for silage), then pasture quality and density will deteriorate, and costs will be incurred either through loss of feed production, loss of feed quality, and/or the expenses involved in regaining pasture control (eg topping). The problem can compound over successive grazings if not corrected quickly.

Restricted pasture intakes will occur when feed demand exceeds energy supply from pasture, for example during early lactation as spring pasture growth comes off a low base, or in late lactation as pasture growth declines in autumn. Supplements can be used successfully in these situations, with milk production responses of 80 g MS/kg if the feed contains at least 10.5 MJ ME/kg DM (not a problem with grain) and cows are of moderate - high genetic merit.

Remember, the major reason for feeding supplement is to avoid over-grazing and ensure consistent residuals of 1500 – 1600 kg DM/ha so that pasture eaten is maximised. It is sometimes stated that it is not possible to maintain residuals of 1500 kg DM/ha while feeding supplements. Wrong! Figure 2 shows pre- and post-grazing pasture masses measured in a grazing systems experiment in south-west Victoria, Australia, conducted over several years. The pasture growing season in this environment is about 8 months, with a very strong spring peak, and near-zero growth rates in summer. Supplements are essential for adequate cow feeding. The data shown are from just one of the systems compared in this experiment, where pasture silage, lucerne hay, PKE, a summer turnip crop, and grain (approximately 1.6 t per cow per year, equating to about 28% of total feed) were fed on a dominantly pasture diet. These feeds were successfully integrated by monitoring pasture residuals and feed wedge, and adjusting feeding as conditions changed during each season. Post-grazing residuals, round length and cow condition score were maintained at target levels. Cows produced 580 – 600 kg MS per year (close to 100% of liveweight) with overall feed conversion efficiency of around

100 kg MS per tonne DM consumed. Pasture utilisation efficiency was around 0.87 t DM consumed for every 1 t DM grown, and return on assets averaged a very healthy 13%.

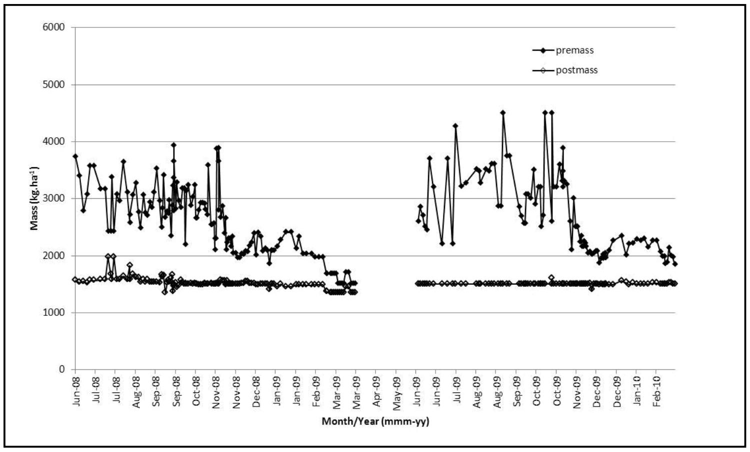

Figure 2. Pre-graze pasture mass (upper line) and post-graze pasture mass (lower line) for perennial ryegrass paddocks in a grazing experiment in south-west Victoria, Australia, 2008-09 and 2009-10 (Tharmaraj et al. unpublished)

Summary of key practices

- For best milk responses from supplement, only offer extra feed when grazing residuals are less than 1500 – 1600 kg DM/ha (indicating a genuine feed deficit)
- Offer only enough supplement energy to bring residuals up to 1500 - 1600 kg DM/ha and maintain round lengths consistent with grazing at 2.5 – 3 leaves
- Monitor pasture growth rates, pasture availability, feed wedge, and round length regularly to accurately calculate the amounts of supplement required

Costs of, and returns from, supplementary feeding

Estimating the true costs of, and economic returns from, using supplements is not simple. A good starting point is to compare feed options in terms of the price per unit of metabolisable energy (c/MJ ME), rather than the price per unit of dry matter (S/tonne). Remember that the supplements listed in columns 3 and 4 of Table 1 are mostly energy supplements (hay and straw

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are the obvious exceptions among the ones listed in the Table). Therefore, it makes sense to choose the most cost-efficient source of energy, and this will be the one that has the lowest c/MJ ME, provided that it meets the minimum energy density required for supporting milk production (at least 10.5 MJ ME/kg DM). The decision criteria will change if there are particular infrastructure requirements associated with particular feeds, and this infrastructure is not already in place on the farm. But, in general, the preferred feed should be the one which supplies energy most cost-effectively.

Information on the ME density that can be expected for different feeds can be found from several sources, for example DairyNZ's Facts and Figures booklet. Bear in mind that the numbers used in these sources come from 'standard' laboratory analyses. There can be a lot of variation between different consignments of the same feed, so it is good practice to obtain a laboratory analysis for feed you are buying to check that the energy density is up to the expected mark.

While the price per unit of supplementary feed is known as a result of each purchase transaction, adding supplements system can involve changes to a range of other costs within the farm business. These include changes in items such as: labour, required for feeding out and associated tasks; machinery and infrastructure required for storage and feeding; operating expenses such as fuel and electricity; and depreciation and interest associated with capital expenditure. The full cost of supplements is therefore the purchase price plus net movements in other costs within the farm business. The latter are almost always upwards, rather than neutral or downwards.

One analysis that is often performed is to calculate the milk income that can be expected from each additional unit of grain fed, and deduct the price paid for each unit of grain to arrive at a margin over feed cost. This type of analysis does not take into account the other costs mentioned above, and so does not give a full picture of the likely economic impact of using grain. It is likely to over-estimate the actual return. It also assumes a certain milk production response for each unit of feed offered. Many factors can affect the response, as outlined in the preceding section, and therefore an element of guesswork is often involved.

A careful analysis of the likely change in return on assets / capital is recommended before a major change in the farm system, such as introducing supplements, is implemented. Return on assets (RoA) or return on capital (RoC) are much better indicators of the economic sustainability of a change than, for example, an analysis of the marginal return for extra milk produced. By definition, RoA / RoC analysis will reveal whether the decision to invest in further capital will lead to sufficient extra profit to justify that investment when the costs of items such as debt servicing and depreciation are included. If the extra profit is not there, then the change may not be economically sustainable and the business may be exposed to greater financial risk.

Summary of key practices

- Compare supplements in terms of price per unit of metabolisable energy, rather than per unit of dry matter. Choose the most cost-effective source of energy, provided the energy density meets the threshold required for milk production.
- Be aware that calculating the marginal return per unit of supplement fed based on expected short-term milk response to the feed omits changes in other costs, and so may underestimate the true cost and overestimate the actual economic benefit.
- Remember that the real value of using supplements in your farm system is in helping maximise pasture eaten. There is generally a close, positive relationship between pasture eaten per hectare and profit, and this is the thing to focus on when considering the economic benefits of using supplements.
- Estimate the return on assets or return on capital outcomes of a major change in farm system, such as introducing supplementary feed, before committing to ensure that the change is financially sustainable.

Differences between grain and other supplements: re-visited

1. Price fluctuations affect the price of grain, whereas the cost of home-grown supplements is more predictable
   a) Other purchased supplements are also subject to price variability. Grain is no better, or worse, in this regard than other sources of supplementary energy.
   b) Forward contracts can be negotiated with grain suppliers to help minimise price variability – as, indeed they can with suppliers of other forms of supplement.
2. Grain is generally more expensive than other feeds
   a) Yes, but there is a lot of variation among other sources of feed in price and also in their energy density.
   b) The energy density of grain is reasonably consistent. However, it is dangerous to assume that all grain consignments will be 'top drawer', and laboratory analysis information is still recommended.

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c) Price comparisons should be done on the basis of MJ ME, rather than just dry matter, with an eye on relative wastage rates of different feeds (usually higher for forage supplements like silage, than for grain).

3. Grain is relatively easy to feed, with low (but not zero) wastage
   a) This assumes grain feeding facilities are installed in the shed. If offered on a feedpad, the ease and wastage advantages are eroded.
   b) There could be some specific situations where feed energy is needed quickly, and with certainty/confidence, for example in the snow storm that hit Southland in spring 2010. Grain is effective in these situations (other feeds such as PKE may be too), but beware the need for an adaptation period (see #5, below).
   c) Wastage in the shed may be low, but don't forget about the wastage that will occur in the paddock through pasture substitution if cows are already well fed.
4. Grain generally has higher energy density than other supplements
   a) This is generally true. However, 'energy is energy', and there are no reports in the scientific literature to suggest that the energy in grain (mainly starch) has any magical properties that set is apart from the forms of energy found in other feeds when supplements are fed on pasture.
5. A period of adaptation required, which is not necessary for other purchased feeds
   a) This can rule out the use of grain for dealing with sudden, sharp energy deficits if it is not already in the diet.

Summing up: When to feed grain, and why

- Grain should only be fed when pasture is already used very well. If there is scope to increase pasture harvest through better grazing and/or pasture management, then do this first before considering supplement use
- Only offer supplementary feed when there is a genuine deficit of energy, causing post-grazing residuals to fall below 1500 – 1600 kg DM/ha (7-8 clicks on the rising plate meter) and/or round lengths that are too short to maximise pasture regrowth
- The focus for supplementary feeding should be squarely on maximising pasture eaten through control of post-grazing residual and rotation length. There is little evidence that feeding beyond these limits will lead to sustainable improvements in profit
- Given that grain is only one of several energy supplement types, and is often dearer than other sources (especially home-grown ones), be clear about how grain differs from other options, and how those differences can be exploited in your system.

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