The science behind supplementary feeding in temperate grazing systems.

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Summary

There are a variety of reasons farmers feed supplements;

These reasons can be summarised into:

- a belief that supplementary feeds prevent body condition score (**BCS**) loss and are essential for getting cows in calf;
- 'ease of management' (e.g., a kg of meal in the shed through spring to supply magnesium and trace elements and improve cow flow);
- 'cow-centric' value judgements (e.g., believe cows are underfed if not supplemented);
- a belief that the increase in milksolids (**MS**) production from supplements increases operating profit.

On the research side:

- a large number of experiments have been undertaken to determine the effect of additional feed on milk and body condition score change;
- some experiments have investigated the effect of supplements on reproduction;
- there is very little information on the effects of supplementary feed on time-budgeting (as a proxy for management ease); and
- an increasing number of science papers have been published on the effects of supplementary feeding on farm costs and profitability.

In general, increasing the amount of supplementary feed in dairy systems in New Zealand and Ireland:

- increases MS production per cow and per ha, but has little effect on body condition loss through early lactation;
- has no effect on reproduction, beyond any differences in body condition score at calving;
- increases farm labour expenses/cow;
- increases the unit cost of MS and reduces profitability, except when used to fill genuine and unexpected feed deficits.

Why do people feed supplements to cows in grazing systems?

We asked farmers in New Zealand and Ireland why they use supplements in their dairy systems. We focussed on farmers using more than 500 kg DM of

supplements/cow. A variety of reasons were given for feeding supplements, but they can be grouped into 4 key areas:

- a belief that supplementary feeds prevent body condition score (**BCS**) loss and are essential for getting cows in calf;
- 'ease of management' (e.g., a kg of meal in the shed through spring to supply magnesium and trace elements and improve cow flow);
- 'cow-centric' value judgements (e.g., believe cows are underfed if not supplemented);
- a belief that the increase in milksolids (**MS**) production from supplements increases operating profit.

There has been considerable research undertaken to understand how supplements affect the cow and the farm system. These studies allow us to determine if the scientific evidence supports the expected benefit. We will address these reasons separately.

Do supplementary feeds prevent early lactation BCS loss?
Answer: No!

Cows lose BCS in early lactation to support milk production. This is a characteristic of all mammals, but is extreme in the modern dairy cow because of the selection for milk production, with no selection for BCS preservation until recently.

For the first 30 days in milk, the physiology of the cow is set to lose BCS by her genetics (McNamara and Hillers, 1986b); nutrition has almost no effect (McNamara and Hillers, 1986a; 1986b; Roche et al., 2009).

For example, when cows were compared on either a total mixed ration in confinement or grazing pasture, there was no effect of feeding on BCS change until approximately 120 days post-calving (see Figure 1; Roche et al., 2007a). On average, mating begins at 60-70 days post-calving (i.e., 80-85 days from planned start of calving). Therefore, cows are approximate 8 weeks into mating before nutrition appreciably affects BCS. Extra nutrients consumed on the total mixed ration treatment went into milk production.

Supplements can affect BCS gain in mid- to late lactation (see Figure 1). However, the effect is relatively small in a grazing system. For example (Roche et al., 2006):

- a high BW New Zealand Holstein-Friesian that received 1 t of barley-maize concentrate at milking throughout lactation was 0.7 BCS units fatter at dry off (i.e., BCS 4.3 vs 5.0);
- a North American or European-type Holstein-Friesian required 2 t concentrate/cow to achieve a similar gain in BCS at dry off (i.e., BCS 3.6 vs 4.5).

In summary, nutrition does not affect BCS loss during the first 5 weeks post-calving and has very little effect for the first 120 days in milk. Simply put, if cows are fed

more in early lactation, they produce more milk. Results from research undertaken in pasture systems suggest that 2-3 kg/d of a high starch concentrate for 100 days or 4-5 kg DM maize silage or PKE:

- in spring, will not materially affect BCS loss or gain;
- in autumn, will increase BCS gain by 0.2-0.3 BCS units at dry off.

In other words, the effect of supplements on BCS during lactation is very small.

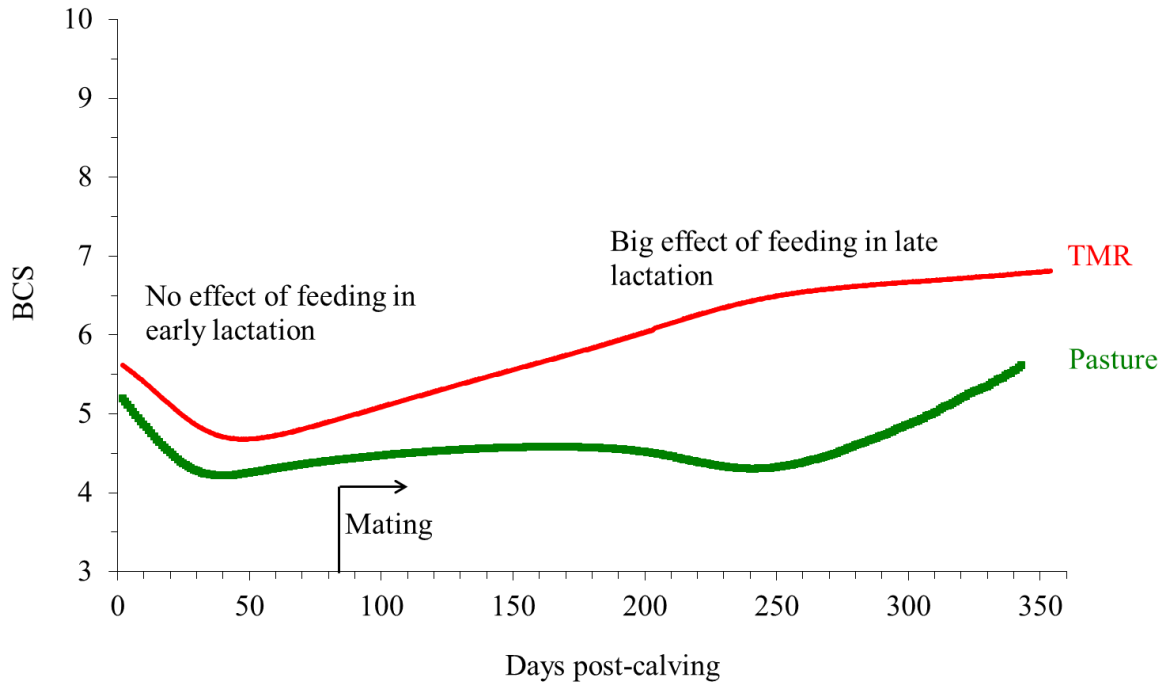

Figure 1. Effect of nutrition on BCS change through lactation (Roche et al., 2007a).

Do supplementary feeds increase 6-wk in calf rates?
Answer: Maybe! The answer to this question depends on when the supplements are fed.

If supplements are fed in the autumn before mating to increase BCS at calving, then they will reduce the time taken for a cow to start cycling after calving and, therefore, will increase the likelihood of late-calving cows getting in calf during the first 6 weeks (Roche et al., 2009). However, calving BCS targets can also be achieved by drying the cows off a little earlier.

However, supplementary feeds in early lactation have very little effect on reproduction (Roche et al., 2011).

1. although BCS at mating is important (Figure 2; Roche et al., 2007b), this must be put in context. New Zealand data indicate that increasing BCS at mating by 1 unit (e.g., from 3.5 to 4.5) will increase herd 6-wk in-calf rate by 6%, everything else remaining the same. This is a very large difference in BCS;

2. as stated previously, supplementary feeding in early lactation has very little effect on BCS;
3. international research has indicated that feeding starch through early lactation may reduce the time taken for cows to cycle after calving, but will reduce pregnancy rates to AI (Roche et al., 2011);
4. analyses of farm data indicate no relationship between feeding level and reproduction.

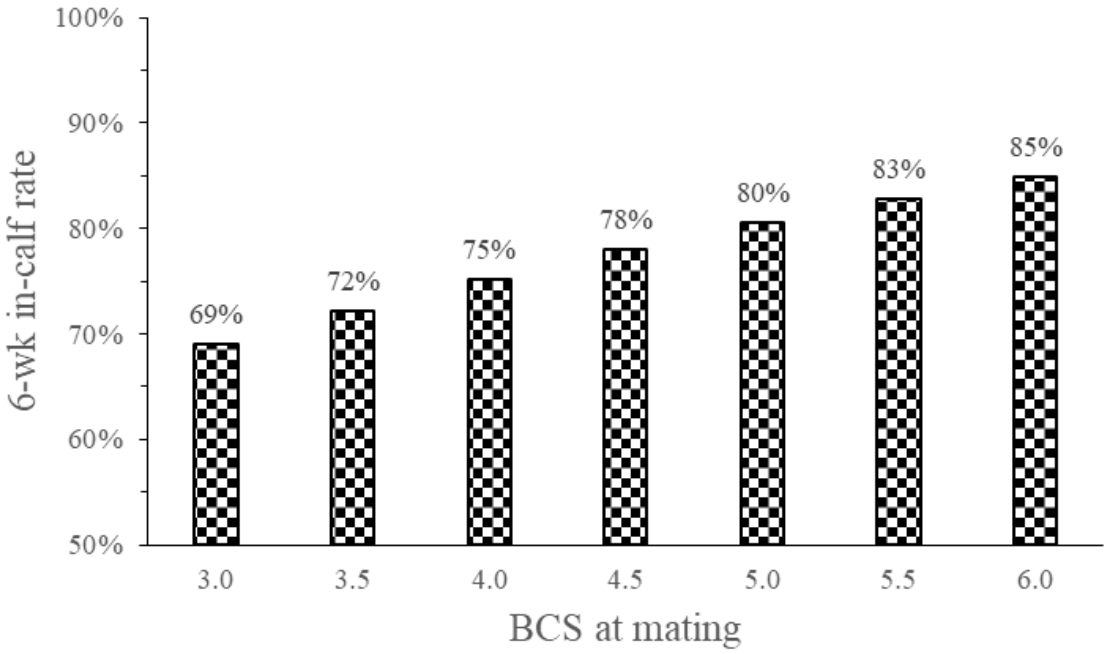

Figure 2. The relationship between BCS at mating and 6-wk in-calf rate (source: Roche et al., 2007b).

In summary, feeding during the previous dry period and the length of the dry period affect BCS at calving. This has an effect on subsequent mating success: ideal calving BCS have been previously defined as 5.0 (10-point scale) for mature cows and 5.5 for heifers and second calvers. However, supplementary feeding during early lactation has very little effect on reproductive outcomes.

Are cows less hungry when they consume supplementary feeds?
Answer: Yes and No! As with most things in life, it's complicated!

When cows consume a feed (i.e., a supplement or pasture), the products of digestion signal to the brain that she has eaten and her hunger diminishes. Because of this, a cow refuses pasture after consuming a supplementary feed (i.e., substitution). In other words, because she was fed a supplement, she was less hungry and, as a result, reduced her intake of pasture (Stockdale, 2000; Bargo et al., 2003; Roche, 2017).

However, the effect of supplementary feeds on hunger is short term; hunger is driven by a complex accounting system in the brain.

- when a cow consumes more feed, she produces more milk;
- because she's produced this extra milk, her body tells her brain that she needs more feed (i.e., she becomes hungry);
- it is the balance between what she eats and what she produces that reflects whether her needs are met;
- hunger, therefore, in the longer term, is reflected in BCS; as stated earlier, supplements have very little effect on BCS.

It could, therefore, be concluded that offering a cow supplements does not reduce hunger.

When we have measured the concentration of hormones in blood that regulate hunger and satisfaction, we find that hunger hormones decline after being fed a supplement (Roche et al., 2008). Cows, therefore, reduce their time spent grazing and how hard they graze (Sheahan et al., 2011; 2013b). However, concentrations of these hormones return to normal shortly afterwards (Sheahan et al. 2013a), showing that the 'reduction in hunger' from feeding a supplement is short lived.

It doesn't matter if the supplement is fed in the shed or on a pad before or after grazing, or in the paddock, the reduction in grazing time each day is the same. For example, Sheahan et al. (2013b) reported on an experiment in New Zealand, where cows reduced their time spent grazing by the same amount in the morning, irrespective of whether they received their supplement at the morning or afternoon milking.

In summary, feeding supplements probably reduces hunger in grazing cows temporarily; that's what causes the cows to reduce their intake of pasture (substitution). However, because the cows reduce their intake of pasture and increase their milk production, the effect on hunger is short lived and the hormones controlling hunger and satisfaction quickly return to normal.

Does offering supplements reduce the workload on farm?
Answer: Probably not.

There's very little scientific information on labour budgets under different dairy farm systems or on the labour effects of intensifying a grazing farm through supplementary feeding. Cows/labour unit are much greater in the New Zealand grazing system than, for example, in a housed system in North America, reflecting the number of tasks to be undertaken in the housed system. However, this is an extreme comparison and may not reflect the effect of increasing feed use in a grazing system.

As a way of answering this question, we could look at the labour expenses in low feed input and high feed input systems. Macdonald et al. (2017) reported on differences in

labour expenses between System 1-2 (low feed input) and System 4-5 (high feed input) farms in New Zealand during 2012-2014. On average:

- total labour expenses/kg MS were greater in the System 1-2 farming system ($1.12 vs. $0.98); and
- total labour expenses/ha were greater in the System 4-5 farming system ($1086 vs 1287).

However, neither of these are good measures of the amount of work being undertaken per person on the farm. Econometric modelling exercises weight labour expenses as 85%/cow and 15%/ha. Therefore, the important metric to consider is labour expenses/cow. In the 3-year dataset presented by Macdonald et al. (2017), wages/cow, including associated costs, were 30% greater in System 4-5 farms ($607 vs $807) and total labour expenses/cow were 5% greater ($1086 vs. $1247) compared with System 1-2 farms.

In summary, therefore, there is no evidence that use of supplementary feeds reduces the workload on farms. In fact, if labour expenses/cow are a proxy for the amount of work that needs to be undertaken/person, use of supplementary feeds increases labour input.

Does offering supplements increase milksolids production?
Answer: Yes.

This is the easiest question to answer. In general, when supplements are offered to grazing dairy cows, either to fill a feed deficit or to increase stocking rate, they will increase MS/ha and, in many cases, MS yield/cow.

The response to supplements varies. Reviews of published research have estimated the response to supplements at 1 kg milk and ~80 g MS/kg supplement DM (Stockdale, 2000; Bargo et al., 2003). However, a recent analysis of the published literature suggests the average response is much lower (0.64 kg milk and 50g MS; Poole et al., 2018). On farm, the estimated average response to supplements is:

- 70-80 g MS/supplement DM in New Zealand (Neal, unpublished); and
- 55-60 g MS/kg supplement DM in Ireland (Ramsbottom et al., 2015).

The response varies with farm management. For example, Poole et al. (2018) reported that the response declined by 10% with every 1 cm increase in post-grazing residuals.

In summary, MS production/ha increase with greater use of supplementary feeds, but it is difficult to predict the actual response.

Does offering supplements increase profitability?
Answer: No.

The profitability of supplement use has been the subject of much debate during the last 20 years. However, recently, analyses of farm system experiments (Macdonald et al., 2017) and farm databases (Ramsbottom et al., 2015; Ma et al., 2018; Neal and Roche, 2018) have concluded that:

- at best, increasing the use of supplements on grazing dairy farms has resulted in no change to Operating Profit (Neal and Roche, 2018), although Operating Expenses/kg MS have increased; or
- Operating Profit and Return on Assets has declined with increasing supplement use (Ramsbottom et al., 2015; Ma et al., 2018).

In both NZ and Irish analyses of dairy farm databases, profitability declined with increasing use of supplement. This is because the cost of the marginal MS produced was, on average, greater than the MS price. For example, Ma et al. (2018) reported that the average marginal cost of MS produced from supplementary feeding in NZ was between $7.50 and $7.66 during 2011-2013. Therefore, milk price would need to be greater than $7.70 for the additional milk to return value to the farmer. Similarly, in Ireland, Ramsbottom et al. (2015) reported that average cost of marginal milk was ~€0.45, a milk price rarely received.

A recent analysis of a farm system experiment in New Zealand has provided some clarity on the reasons for reduced profitability with greater feed use and provided some guidance on profitable use of supplements. Macdonald et al. (2017) investigated the effect of using supplements to:

a) fill genuine feed deficits; or
b) increase stocking rate.

Interestingly, the MS production response to the supplement was the same for both strategies (90-95g MS/kg DM maize grain or 75-80 g MS/kg DM maize silage offered: 7.25g MS/MJ ME offered). However, the cost of the marginal milk was:

a) $5.54 (maize silage) and $6.33 (maize grain) when used to fill deficits; and
b) $7.81 (maize silage) and $7.97 (maize grain) when used to increase stocking rate.

These results highlight the effects of the two different strategies on profitability.

- Using supplements to fill a genuine feed deficit can be profitable, but the supplements should be purchased on a c/MJ ME and not how much MS/kg supplement DM.
- If you have a ‘genuine feed deficit’ every year, your farm stocking rate is probably too high and you should consider reducing cow numbers to reduce/remove the reliance on supplementary feeds.

In summary, the scientific evidence does not support the use of supplementary feeds in a grazing system to increase profitability, except when filling an unplanned feed deficit. Using supplements to increase stocking rate consistently reduces profitability.

Conclusions

Farmers provided many reasons for using supplements in grazing systems. In brief, the reasons relate to a focus on ensuring animals are well fed, making farm management easier, and improving profitability. The available science does not support the use of supplementary feeds for these reasons.

Short-term and tactical use of supplements can make managing a farm easier because of a feeling that animals are well fed during poor pasture growth or utilisation conditions and, in these circumstances, it may not negatively affect profitability. However, longer-term, planned use of supplement to increase stocking rate has been shown to reduce both Operating Profit and Return on Assets.

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