HOW FAR CAN WE GO ON GRASS?

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Summary

- Milk production for cows grazing pasture is limited by the amount of feed that can be grown and harvested.
- Herbage DM allowance and stocking rate trials, combined with demonstration farm data, show that milksolids production > 500 kg MS/cow/year and > 1800 kg MS/ha is achievable in pasture-fed dairy cows with a low quantity (< 200 kg DM/cow) of bought in supplement.
- Increasing pre-grazing herbage mass above the currently recommended guideline of 2800 to 3200 kg DM/ha has a demonstrated ability to increase the amount of herbage grown and harvested.
- Tactical spring grazing management that uses higher post-grazing residuals has the potential to increase the quantity of herbage grown, but effects are yet to be realised on farm.
- Offering a fresh herbage allocation in the afternoon, rather than the morning, offers prospects to improve milk production with no increase in DM intake.
- Including herbs in a pasture mixture with grasses and legumes appears to have a small impact on milk production compared to grass-legume pasture mixtures, but may offer marked environmental benefits through reduced N loading in urine patches.

Introduction

This workshop will address constraints to milk production in pasture-based systems, specifically those related to the quality and quantity of herbage grown and amount harvested per cow. The merits of strategies, such modification of grazing management and herbage allocation, choice of pasture species and cultivar, to push the boundaries of milk production from pasture will be considered, along with implications for nutrient limits.

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Is milk production limited on pasture?

Experimental and farm systems studies show clearly that milk production is often limited in pasture based dairy farms by the amount of pasture that can be grown and harvested. For example, in a comparison of strains of Holstein-Friesian dairy cows at different feed allowances, milksolids yield increased from 436 to 535 kg MS/cow as feed allowance increased from 5.6 to 7.0 t DM/cow (Macdonald et al. 2008). In a study of early lactation dairy cows, milk production was 15.3 kg higher for cows fed total mixed ration (43.0 kg milk/cow/day) than similar cows fed pasture (27.6 kg milk/cow/day) (Kolver and Muller 1998). The difference was primarily associated with DM intake; partitioning the 15.3 kg difference in milk yield into different components showed +9.4 kg was associated with DM intake, +3.7 kg with walking and grazing activity, +1.8 kg with the cost of urea excretion, +1.1 kg with milk composition and -0.7 kg with live weight. In farm systems studies, (Pastoral 2, Phase 2), high milksolids production per cow (486 kg MS) and per ha (1700 kg MS) has been achieved when lower stocking rate (3.5 cows/ha) has been used to increase herbage allowance and daily pasture DM intake (average 15. 1 kg DM/day over lactation) (Table 1).

Table 1. Key physical performance of the Higher Input (HI) and Lower Input (LI) systems, Canterbury, averaged over four seasons from October 2011 to May 2015. Milking platform data only, wintering off excluded. N leaching estimates were modelled in Overseer version 6.2. Data from Clement et al. (2016).

	HI	**LI**
Stocking rate (cows/ha)	5.0	3.5
Cow genetic merit (Breeding worth)	133	140
Pasture grown (t DM/ha)	18.0	16.5
Daily pasture intake (kg DM/cow)	12.4	15.1
Grain fed (kg DM/cow)	523	64
Total supplement fed (kg DM/cow)	940	325
N fertiliser applied (kg/ha)	304	156
Pasture N%	3.6	3.5
MS/cow (kg)	449	486
MS/ha (kg/ha)	2242	1700
N leaching overseer (kg/ha)	48	33

Is it getting harder to feed cows to potential on pasture?

There appears to be a widening gap between realising the DM intake potential of cows from pasture and the ability of pasture to provide this. Bryant and Amer (2014) noted that every year the New Zealand national herd improves by an average of 11 breeding worth (BW) units per cow as measured by the New Zealand BW index; this is equivalent to $11 per 5 t DM consumed on farm per year. At this rate of realised, on-farm genetic gain, New Zealand farmers are benefitting from an extra 23 kg MS per cow and a $107 increase in profit per 5 t DM consumed every 10 years (Bryant and Amer 2014). The increase comes with a ‘cost’ of increased DM intake of approximately 16 kg DM/cow per year, or a 0.32% increase in intake per year. When viewed another way, if feed supply does not increase at the same pace, then, in theory, the number of cows farmed should be reduced by 0.32% per year; otherwise, gains in animal genetics will not be expressed. This implies that either an increase in DM consumed from pasture of 0.32% must be achieved per year. This is equivalent increase in DM grown of 0.4% per year, assuming 80% of total pasture grown is utilised through grazing, or stocking rate must decrease by 0.32% per year to maintain a balance between feed supply and demand.

Will improvement in pasture growth with new genetics be able to achieve this? A rate of gain in perennial ryegrass DM yield of 0.5% per year suggests that the rates of improvement in plant and animal productivity in New Zealand are in balance. However, as noted above, the quoted animal genetic gain is being achieved on farm now at 0.32% higher feed demand per year per cow, whereas the 0.5% DM yield gain estimate comes from small-plot trials where pastures are managed much more carefully than they are on farm and is gain per hectare. Crush et al. (2006) questioned whether any gains in pasture DM yield have been achieved in well managed pastures in recent decades. Indeed, an analysis of the trend in total annual herbage accumulation measured in farmlet trials in the Waikato region of New Zealand from 1979 to 2013 raises the same question (Glassey 2011). There was the obvious among-year variation in growth. Besides that, the only discernible change in pasture productivity was related to the introduction of N fertiliser starting in 1993, which lifted overall yields by 2–3 t DM/ha per year. While progress has been made in the seasonality of production, it is thus unlikely that progress in improving DM yield is keeping up with the improvement in genetic merit (and associated

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DM intake demand) of cows, particularly when set against a background of reducing inputs of N fertilizer inputs to reach environmental goals. This raises the question, of what are the strategies beyond simply improved pasture genetics (e.g. new cultivars) that may lead to more feed being grown and harvested, or better utilisation of available feed for milk production?

Strategies to grow and harvest more feed

Higher pre-grazing herbage mass

There are opportunities to improve milksolids production and amount harvested by using higher pre-grazing herbage mass than currently recommended in grazing guidelines (2800-3200 kg DM/ha). The basic principle that "grass grows grass" has been well documented from earlier studies; with more leaves, the pasture captures more light, has greater photosynthesis capacity and grows faster. The excellent theoretical analysis of regrowth dynamics of pastures (Parsons and Penning 1988) in the 1980s pointed this out clearly.

More recent empirical evidence from grazing studies with perennial ryegrass-based pastures (Chapman et al. 2012) indicates that lengthening the regrowth interval to increase pre-grazing herbage mass could increase the pasture grown. When this approach was applied in a scenario analysis to New Zealand dairy grazing systems (Chapman et al. 2014; Chapman 2016), it has been indicated that lengthening the regrowth interval to increase pre-grazing herbage mass could increase pasture grown and used by around 7%, with commensurate increase in MS/ha (i.e. all extra feed goes straight into extra milk) and profit by 10% while retaining good control of grazing residuals and pasture quality.

Some evidence of this has been observed on the Lincoln University Demonstration Dairy Farm (LUDDF) over the past two seasons (2014-2016), where stocking rate has been reduced from 3.92 to 3.50 cows/ha and N fertilizer input from c. 350 kg N/ha to 143 to 179 kg N/ha. Milksolids production has been high in both the 2014/15 (498 kg MS/cow, 1742 kg MS/ha) and 2015/16 (520 kg MS/cow, 1800 kg MS/ha) seasons relative to earlier seasons (e.g. 2012/13, 477 kg MS/cow, 1878 kg MS/ha) where higher stocking rates and greater N fertilizer inputs were evident (LUDDF Focus Day Handout 5th May 2016). One of the key reasons for these high production levels is that LUDDF has increased its pre-grazing herbage mass by approximately 200 kg DM/ha (3328 kg DM/ha from September to January; 3625 kg DM/ha from February through April), so leading to greater herbage grown, with an estimated 4986 kg DM pasture harvested per cow from the milking platform in 2015/16 season. Essentially, LUDDF has moved from grazing ryegrass at around 2.5 leaves/tiller to around 3 leaves/tiller. Post-grazing residual has remained similar to previously and a consistent, even post-grazing residual remains. Running higher pre-grazing herbage mass has meant that grazing rounds are longer (by an average of 6 days) and each paddock has been grazed 1-2 times less over the season.

One of the concerns about adopting this approach of higher pre-grazing herbage mass has been that it places the system closer to the edge of a decline in pasture quality. The metabolisable energy content of the pasture is still high (12+ MJ ME/kg DM) at the 3 leaf/tiller stage of perennial ryegrass growth, but beyond this it starts to drop off, due to accumulation of dead material and stem material. Having higher pre-grazing herbage mass means the farm is growing more, but moving past 3 leaves/tiller leads to quality issues more quickly. This places a priority on monitoring and controlling pasture quality when necessary (e.g. pre-graze and post-grazing mowing, making silage). While there is limited evidence to suggest that pre-grazing mowing increases DM intake compared to grazing standing herbage when offered at the same herbage allowance (Kolver et al. 1999; Bryant et al. 2016), it does return pastures to a low and even post-grazing residual and enable pasture quality to be maintained.

A further factor that may assist with use of higher pre-grazing herbage mass on farm is the use of tetraploid perennial ryegrass cultivars. Anecdotal evidence indicates that whereas cows may struggle to graze a straight diploid ryegrass >3300 kg DM/ha, a tetraploid or tetraploid/diploid mix will typically still be well grazed at 3600 kg DM/ha. This has been supported by experimental data (Bryant and Edwards 2012). In a study comparing milk production and nitrogen use efficiency of late lactation dairy cows grazing a diploid and tetraploid perennial ryegrass cultivars at low (2900 to 3200 kg DM/ha) and high (3800 to 5000 kg DM/ha) pre-grazing herbage mass, milksolids production was decreased at high herbage mass (-0.29kg MS/cow/day) in the diploid but unaffected by herbage mass (+0.07 kg MS/cow/day) in the tetraploid.

Altered spring grazing management

A further approach to examine is to alter grazing management, particularly in spring, in order to increase herbage production. There are various schools of thought on the role of grazing in spring in promoting DM production and quality. One line of thinking is that hard consistent grazing is needed to prevent the expression of flowering in the grass plant in spring, and so the decline in quality and DM production (McKenzie et al. 2006). This has led to development of grazing management based on low, consistent post-grazing residuals (7 clicks

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on RPM, 3.5 cm compressed pasture height) as a basis for ensuring high pasture quality (ME) and a high quantity of ME harvested per ha. An alternative line of thinking is less intense grazing may allow better provisioning of daughter tillers with consequence of improved DM production in summer an autumn. This is based on the premise that daughter tiller development is inhibited by severe early defoliation, with daughter tiller development and summer growth enhanced by allowing the reproductive parent tiller to develop to the early flower stage before being removed by defoliation (Matthew et al. 1991).

Da Silva *et al*. (2004) examined this concept in a series of three trials in perennial ryegrass-white clover pastures in the Manawatu. Compared to conventional close grazing (grazing to residual of 30-50 mm every 20-21 days in spring and 28-30 days in summer, residuals *c.* 1600 to 2700 kg DM/ha), late control (grazing or cutting to residual of 80-100 mm every 20-21 days in spring, residuals *c.* 2000-2700 kg DM/ha) followed by a switch to hard grazing (30-50 mm) at anthesis (28-30 days in summer, residuals *c*. 1600 to 2700 kg DM/ha) resulted in an average herbage production increase of 24% in October and November and 22% in January to April. In work on the Lincoln University Research Dairy Farm, DM production, botanical composition and pasture quality have been measured from perennial ryegrass-white clover pasture that has been (i) grazed to low residual all year (7.5 clicks on rising plate meter) or (ii) grazed to higher residual (9 clicks on rising plate meter) in spring until anthesis (early seed head stage) before grazing to a lower residual (7.5 clicks on rising plate meter) or rest of year. Data averaged over two years shows greater DM production from the high to low residual than the hard residual treatment (15848 versus 13885 kg DM/ha), with this mainly due to greater summer and autumn production. Further, there was little difference in ME and crude protein of samples collected to ground level. This approach presents appealing opportunities to improve milk production through greater herbage production, although work is required to implement at the whole-system level (Bishop-Hurley et al. 1998).

Timing of herbage allocation

The time of day at which herbage is allocated to dairy cows represents a further opportunity to improve the quantity and quality of herbage harvested and milk production. The cow’s diurnal grazing pattern is made up of decisions within each day of ‘when’ cows begin to graze, at ‘which’ frequency and ‘how’ to distribute grazing events. Cows typically have 3 to 5 grazing events per day, with the major grazing event occurring in the early morning and late afternoon/early evening. The afternoon grazing event is generally the longest and most significant in terms of herbage DM intake. There are also changes in plant composition on a daily basis. Due to photosynthesis and transpiration during the day, herbage accumulates DM, sugars and essential fatty acid; this, in turn, dilutes the fibre and protein contents and may facilitate herbage particle breakdown during ingestion of herbage (reviewed by Gregorini 2012).

Several overseas studies have focussed on how the timing of herbage allocation may be better matched to the diurnal fluctuations of herbage chemical composition and diurnal grazing pattern. When new pasture was allocated during the afternoon, animals typically displayed fewer, longer and more intensive grazing bouts late in the afternoon and early in the evening compared with when the new daily pasture was given in the morning. This simple change, of afternoon versus morning pasture allocation, led to significant improvement in milk yield of the order of 0.8 to 2.5 kg of milk/cow/day studies (reviewed by Gregorini 2012). Of particular note, none of these studies reported differences in daily herbage DM intake. Thus, the results indicate an increase in nutrient intake by animals allocated to new pasture during the afternoon (Gregorini 2012).

However, in studies conducted at Lincoln University, with dairy cows grazing irrigated dairy pastures in late lactation, the effect of offering a new break in the afternoon rather than the morning has been less clear. Both Chen et al. (2016) and Allen (2010) noted no difference in milksolids production when dairy cows were offered the same daily allowance on herbage in the afternoon compared to the morning, although some environmental benefits were demonstrated with less nitrogen excreted in urine from dairy cows with an afternoon herbage allocation. Research is now progressing to address some of the reasons for differences (herbage quality, DM intake potential) in the effect of diurnal herbage allocation between New Zealand and overseas studies to further scope the potential of timing of herbage allocation to improve milksolids production.

Using pastures with herbs

A further approach to consider is whether changing plant species away from the dominant perennial ryegrass-white clover pasture will improve pasture grown and harvested. Recent research has focussed on the use of herb species (chicory and plantain) in pastures to improve milk production and reduce environmental impact, notably nitrate leaching (Totty et al. 2011; Edwards et al. 2015). A series of studies show including herbs in pasture leads to reductions in

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the urinary N loading in urine patches (Totty et al. 2011; Box et al. 2016). However, when offered at similar allowances, milksolids production per cow is similar from perennial ryegrass-white clover and more diverse pastures containing chicory and plantain (Totty et al, 2011; Woodward et al. 2013; Bryant et al. 2016). Herbage production studies demonstrate similar herbage production of perennial ryegrass-white clover and more diverse pastures under irrigation, although diverse pastures are less restricted by a temporary restriction of irrigation (Nobilly et al. 2013). Modelling the potential of diverse pastures to reduce leaching at the whole of farm scale has indicated a reduction of 11% and 19%, where 20% and 50%, respectively, of the farm area was sown to diverse pastures (Beukes et al. 2014).

Conclusion

Milk production for cows grazing pasture is limited by the amount of feed that can be grown and harvested. Herbage DM allowance and stocking rate trials show that milksolids production > 500 kg MS/cow/year and > 1800 kg MS/ha is achievable in pasture-fed dairy cows with a low quantity (< 200 kg DM/cow) of bought in supplement. Increasing pre-grazing herbage mass above the currently recommended guideline of 2800 to 3200 kg DM/ha, altered spring grazing management, and diurnal patterns in allocation of forages are strategies that may be used to improve milk production from pasture through promotion of greater DM intake or better utilisation of forages.

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