March 2018

Issue 37

Technical Series IN BRIEF

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Dairy NZ

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ISSN 2230-2395

DNZ04-037

Caring for cows on stand-off pads

Taking cows off the paddock may protect pasture, but how does it affect the cows? Although the New Zealand dairy industry is pasture-based, hybrid systems where cows spend part of the day off the paddock are becoming more common. Around 24% of dairy farmers now use covered or uncovered off-paddock areas, particularly in winter[1].

Cheryl O'Connor, Jim Webster, Suzanne Dowling, **AgResearch**
Helen Thoday, **DairyNZ**

Over the last three years, these systems have been studied to inform and assist farmers to manage off-paddock facilities in a way that achieves good cow welfare outcomes.

Lying time

Lying down is a critical behaviour for cows and they will typically spend 10-12 hours a day lying, if allowed to fully express this behaviour[2]. The New Zealand Dairy Cattle Code of Welfare and the dairy industry recommends minimum lying times of eight hours per day, as cows display signs of welfare compromise if lying times are less than eight hours per day[3].

Although daily lying time is well-established as a measure of cow comfort, a more reliable measure requires detailed observation of individual cows for extended periods[4] or accelerometer devices (activity loggers) attached to the cow.

Key findings

- Over five weeks, the stand-off pad surfaces deteriorated to the extent that daily cow lying time rapidly declined below the recommended minimum of eight hours per day.
- Cows prefer clean and dry bedding. Stand-off pad bedding with a moisture content exceeding 75% does not provide an acceptable lying surface for cows.
- As the pad surface deteriorates, more cows will swap grazing time to lie down when on pasture.
- Stand-off pads must be well-maintained and replenished regularly to achieve adequate cow lying times and welfare.
- A new Tipping Point Calculator now predicts the maximum hours of use and appropriate stocking density for good cow welfare on stand-off pads. Visit dairynz.co.nz/tpc.

Just observing if cows are lying or not is insufficient, as lying-deprived cows will eventually lie down on an uncomfortable surface, though their total lying time will be less than the minimum recommendation.

So how can farmers identify if cows are receiving adequate rest? To answer this, we looked at different options, investigating the relationship between lying time, other behaviours and bedding quality for dry cows kept on woodchip-based uncovered stand-off pads. This was undertaken at AgResearch's Tokanui research farm in the Waikato.

Cows were on the stand-off pad for 18 hours per day over five weeks (June to early July) during 2015 and 2016 winters, with the remaining six hours per day on pasture. In 2015, two herds of 100 cows were kept at a space allowance of 5.4 m^2/cow and in 2016 this was compared to 7.85 m^2/cow in smaller groups of 30-40 cows.

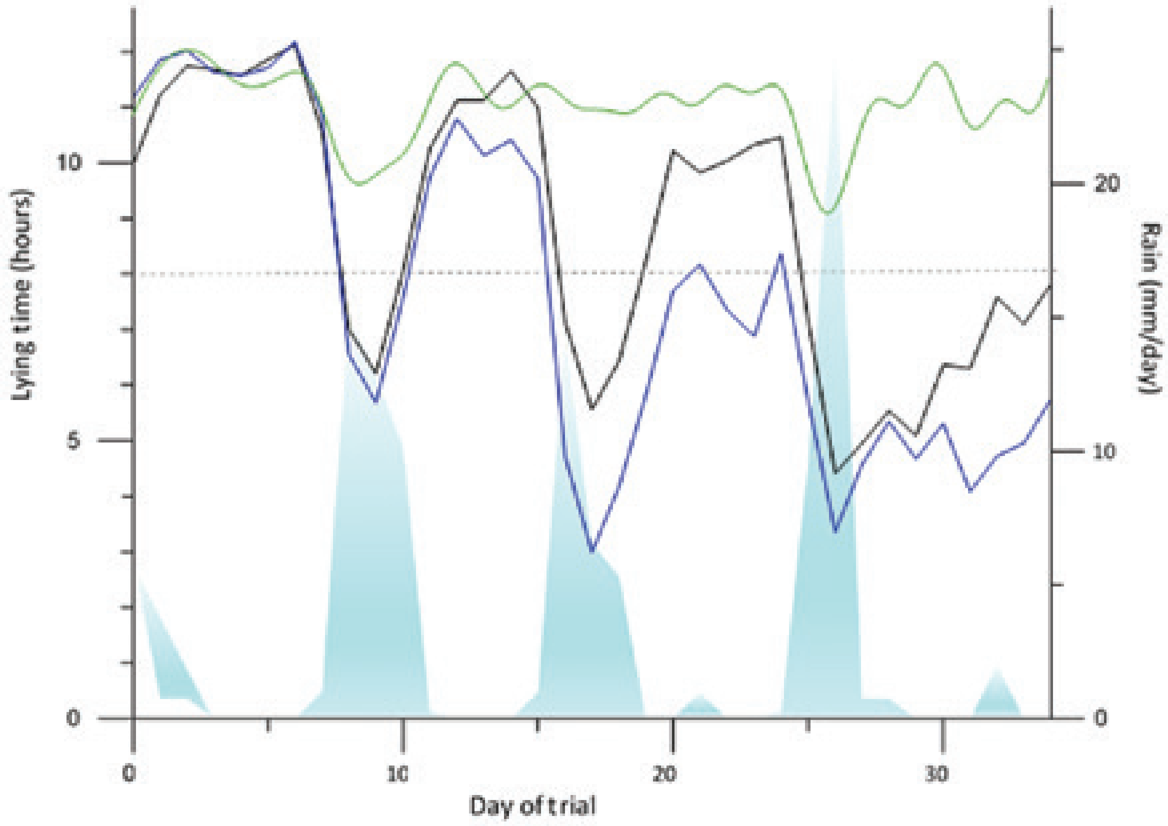
Lying times declined with pad use

Daily lying times met recommendations while the bedding was in good condition (10.5 hours per day; Figure 1).

A small herd of cows kept on woodchip bedding that was refreshed three times a week maintained a consistent daily lying time of 10.5 hours per day. However, for the main herds, lying time declined to less than six hours per day by the fourth week. In fact, the herd's daily lying time was less than the minimum recommended requirement of eight hours for almost half the days of the trial, including the last 10 days (Figure 2).

Reduced lying times coincided with heavy rainfall events (over 10 mm per day; Figure 1). For every millimetre of rainfall on a given day, lying time per cow decreased by an average of 13 minutes. In 2016, there was little rain until the end of June. Therefore, on wet days most of the herd lay down for less than the minimum requirement of eight hours per day.

Figure 1. The total daily lying time for cows on a woodchip-based uncovered stand-off pad for 18 hours per day and pasture for six hours per day.



These represent the lying time for two herds that did not have bedding replenished. Their lying time trended down over the five-week trial.

One herd (with woodchip bedding, refreshed regularly) achieved adequate lying time throughout the study.

This represents the minimum daily recommendation of eight hours lying time per day.

Rainfall (mm/day) during the trial period is also shown and coincided with reductions in lying time.

Rainfall affects lying time

Cows reduced their lying time below the minimum recommendation of eight hours per day on days when moderate to heavy rainfall occurred. However, where cows had access to fresh bedding, adequate lying times were maintained throughout the study.

Moisture content key to welfare

The key factor that determines lying time, and therefore cow welfare on off-paddock facilities, is bedding quality. What 'quality' bedding means for a cow was investigated by measuring a variety of bedding parameters from 25x40 cm quadrat samples across each stand-off pad over the five weeks cows were on woodchip-based pads for 18 hours per day, and across both winters.

The key finding was that the bedding's moisture content increased from 60% to 80% over five weeks in both years (Figure 3). When the moisture content exceeded 75%, daily lying times were less than the recommended eight hours/day. However, for bedding regularly refreshed with woodchips, the moisture content remained less than 65% throughout the trial.

To further describe the bedding quality, a visual assessment of the percentage of woodchips to 'muck' (a mixture of faecal material and mud) and the muck's depth were also taken.

Not surprisingly, the percentage and depth of muck also increased significantly over the trial period on those stand-off pads where the bedding was not refreshed. Many studies show that cows indoors prefer to lie on dry surfaces[5]. We have demonstrated that New Zealand 'outdoor' cows also clearly prefer, and spend more time lying on, clean and dry woodchip compared to wet or muck bedding. Studies show the aversion against lying on wet woodchip bedding was particularly strong[6]. Our research has also confirmed this.

Cows prefer dry, clean bedding

Cows reduced lying times to below the recommended amount when woodchip bedding exceeded 75% moisture content. Cows prefer lying on clean and dry bedding.

On-farm cow comfort indicators

A new Tipping Point Calculator, which uses the lying time, bedding quality and rainfall information, can be used to estimate the maximum hours of use and appropriate stocking density for good cow welfare on stand-off pads.

The user simply enters projected stand-off pad use information: the number of cows, length of time on the pad, the facility size and average rainfall. It then calculates the tipping point when cow lying time is likely to reduce.
Visit **dairynz.co.nz/tpc.**

Figure 2. Percentage of the herd that achieved the minimum daily lying time of eight hours per day when off pasture, on a woodchip-based uncovered stand-off pad (without bedding refreshment) for 18 hours per day over five weeks, during two winter periods. Percentages in 2016 were higher due to less rainfall occurring in the first four weeks of stand-off pad use.

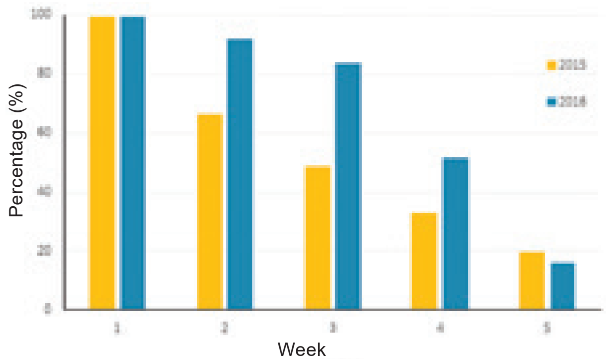


Figure 3. Wetness (moisture content) of woodchip bedding on an uncovered stand-off pad increased over the five-week monitoring period, when used by cows for 18 hours per day during winter.

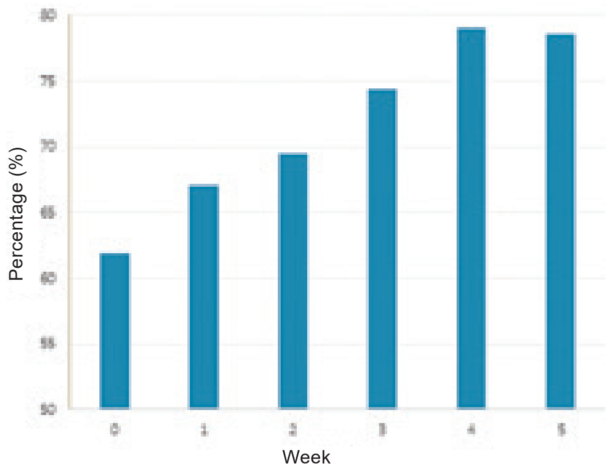
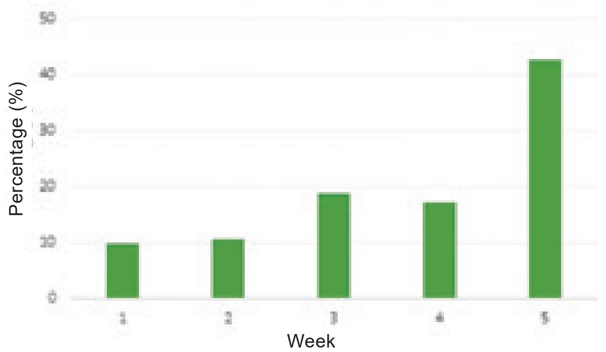


Figure 4. The percentage of the herd observed lying down at the third hour while at pasture increased over the five-week trial period. This reflected declining quality of bedding and, subsequently, decreased lying behaviour on the stand-off pad, utilised for 18 hours per day.



Other useful indicators of cow comfort have also been developed. The visual assessment of a boot imprint, woodchips and liquid pooling have been combined into a 'gumboot score' (Figure 5) to assess bedding quality and indicate when the surface is too wet to meet cows lying needs (Score 3: >75% moisture content).

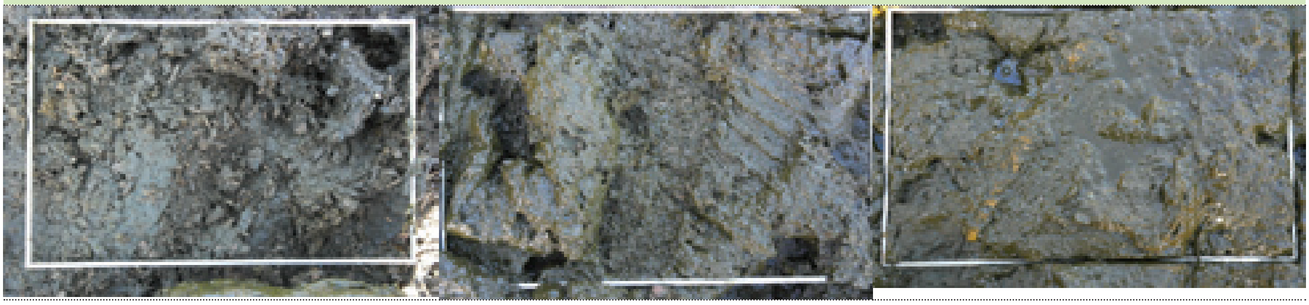
Another on-farm indicator is cow behaviour when they return to pasture. This study found that the lying pattern of the entire herd changed when the stand-off pad became too wet to lie comfortably (after four weeks), with more cows lying down (Figure 4) sooner and for longer when on pasture.

Is it time to replenish bedding?

The 'gumboot score' and lying behaviour (percentage of the herd lying three hours after they have returned to pasture) can assist decision-making to replenish stand-off bedding and improve cow welfare when stood off-pasture.

Figure 5. Gumboot score for estimating cow comfort of stand-off bedding material. This score combines bedding attributes, visual assessment of a boot imprint, visibility of woodchips and amount of liquid pooling, to help assess when a woodchip pad exceeds 75% moisture content. Score 3 is an unsuitable surface for cows.

1. Dry	**2. Wet**	**3. Sodden**



1. Dry	2. Wet	3. Sodden
• Boot imprint dry and stays there. • Woodchip easily seen. • No pooling.	• Boot imprint wet and less defined. • Woodchip less obvious. • Wet but little pooling liquid.	• Boot imprint disappears straight away. • Woodchip cannot be recognised. • Pooling liquid obvious.

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Unravelling the complexities of endophytes

Knowing the pros and cons of endophyte will help select the best combination of endophyte and ryegrass cultivar to sow in pastures. The industry-developed Endophyte Ratings Tables, the Forage Value Index and AgPest provide key information for decision-making.

David Hume, Alison Popay, **AgResearch**

Since break-through science discoveries in the early 1980s, New Zealand has led the world in understanding the role of fungal endophytes in our agricultural systems and utilising them to benefit our main sown pasture grass – ryegrass.

For farmers though, it can be difficult to determine exactly which endophyte is best for their situation. Here, we delve into the role of endophytes and what to consider when making pasture renewal decisions.

What is an endophyte?

Within many ryegrasses lives a fungal microbe commonly referred to as 'endophyte'. It is naturally occurring and only lives within the grass plant or seed where it is totally reliant on the host to provide food and an environment to live.

The fungal endophyte is responsive to, and synchronised with, the plant's growth. This allows the endophyte to colonise newly-formed grass tillers and seeds. By hosting the endophyte, a unique set of chemical compounds are produced in the grass, which are absent in endophyte-free ryegrass.

These compounds can enhance the agronomic performance

Key findings

- Fungal endophytes are naturally-occurring companions of ryegrass. Endophyte-ryegrass combinations produce a unique set of bioactive chemicals.
- Endophytes help protect ryegrass plants from insect damage, but some can also impair animal performance and health.
- Selected endophytes minimise detrimental effects on grazing livestock but still protect plants against a range of insect pests. The AgPest website (agpest.co.nz) can be used to identify problem insects and management solutions.
- Endophyte is delivered within the ryegrass seed. Endophyte-infected seed should be treated as a perishable product and not stored for extended periods at the retailer or on-farm. Also, sow treated/coated seed.
- For the best ryegrass cultivar-endophyte options for your farm, use DairyNZ's FVI Cultivar Selector Tool (dairynz.co.nz/cultivar-selector) and the Endophyte Ratings Tables (dairynz.co.nz/endophyte).

of the ryegrass by providing protection from insect pests, but some may also be detrimental to the health and productivity of livestock consuming the forage. Research has been able to describe and quantify these unique chemicals and understand their roles in affecting insects and livestock.

Where did endophytes come from and why?

Ryegrasses were introduced to New Zealand in the 1800s by the English settlers when, unbeknown to them, endophyte came along with the imported seed. Ryegrass then became widely naturalised in our pastures, particularly under high fertility.

The advantages to host plants means endophyte presence was unwittingly selected for by plant breeding and through natural selection in pastures. When scientists surveyed New Zealand ryegrass in the 1980s, they found a common type of endophyte now known as 'standard' endophyte (SE). This provides its host plant with protection from a variety of insect pests but is also responsible for animal disorders such as ryegrass staggers and heat stress.

These detrimental effects on livestock are due to particular chemicals (known as alkaloids) produced by the endophyte. When scientists investigated endophytes offshore, they found endophyte strains in ryegrass that differed in chemistry and their effects on insects and livestock.

Several strains were of value to New Zealand farmers, so now the perennial and long-rotation hybrid ryegrass seed market is dominated (>80%) by cultivars sold with 'selected' ('novel') strains of endophyte. Some cultivars of short-rotation hybrid and Italian ryegrasses, and festuloliums, also have selected endophytes. Use of selected endophytes is estimated to benefit the economy by $200 million per annum.

From an agronomic perspective, the different strains of endophyte deliver a range of advantages for plant persistence and dry matter production, as they vary in the level of insect protection they impart to their ryegrass host. Further information is available in the industry-agreed Endophyte Ratings Tables,

Endophyte type and protection against insect pests

Pasture in New Zealand is subject to feeding and damage by a number of insect pests. The control of these pests is mediated through the endophyte within perennial ryegrass, Italian and short term (hybrid) ryegrass and festulolium. The ratings in the following tables are indicative and may vary slightly between cultivars.

	Argentine stem weevil	Pasture mealy bug	Black beetle adult	Root aphid	Porina	Grass grub	Field cricket
			Diploid perennial ryegrass				
AR1	++++	++++	+	-2	-	-	Not tested
NEA2	+++	(++++)	+++	++	Not tested	-	Not tested
AR37	++++1	++++	+++	++++	+++	+	Not tested
SE	++++	++++	+++	++	+	-	Not tested
WE	-	-	-	-	-	-	Not tested
			Tetraploid perennial ryegrass				
AR1	(+++)	(++++)	+	-2	-	-	Not tested
NEA2	++	(++++)	+++	++	Not tested	-	Not tested
AR37	(+++)1	(++++)	+++	++++	(+++)	+	Not tested
WE	-	-	-	-	-	-	Not tested
			Festulolium				
U2	++++	(++++)	+++3	++++	(++)	+++	+++
			Italian and short term (hybrid) ryegrass				
AR1	++	(++++)	+	-2	Not tested	-	Not tested
NEA	Not tested	(++++)	+++	Not tested	Not tested	-	Not tested
AR37	+++1	(++++)	+++	Not tested	Not tested	-	Not tested
WE	-	-	-	-	-	-	Not tested

Key to tables

– *No control*
\+ *Low level control: endophyte may provide a measureable effect, but is unlikely to give any practical control.*
++ *Moderate control: endophyte may provide some practical protection, with a low to moderate reduction in insect population.*
+++ *Good control: endophyte markedly reduces insect damage under low to moderate insect pressures. Damage may still occur when insect pressure is high.*
++++ *Very good control: endophyte consistently reduces insect populations and keeps pasture damage to low levels, even under high insect pressure.*
( ) *Provisional result: further results needed to support the rating. Testing is ongoing.*
1. *AR37 endophyte controls Argentine stem weevil larvae, but not adults. While larvae cause most damage to pastures, adults can damage emerging grass seedlings. In Argentine stem weevil prone areas it is recommended to use treated seed for all cultivars with novel endophyte.*
2. *AR1 plants are more susceptible to root aphid than plants without endophyte.*
3. *Also active against black beetle larvae.*

which are based on scientific peer-reviewed data (dairynz.co.nz/endophyte). Additional information on this site describes the effects of endophyte strains on animal production and ryegrass staggers.

The ideal endophyte would deliver maximum insect protection, with animal production and health equivalent to an endophyte-free ryegrass. Unfortunately, some of the endophyte chemistry that reduces insect attack also negatively affects livestock. This results in the need to select the best endophyte for your farm situation, which may ultimately be a compromise between pasture performance and animal performance.

Correctly identifying your insect pest

When it comes to insects, nothing beats getting down on the ground and correctly diagnosing what is happening in a particular paddock. Often more than one pest is present at any one time or at different times of the year. To help, a web-based application called AgPest (agpest.co.nz) provides practical information for farmers and rural professionals to identify and manage a wide range of pests and weeds.

AgPest email or text alerts to registered users also provide timely information warning of pest issues in a particular region and suggest appropriate management responses, including recommended endophytes.

It's important to note that endophyte does not provide protection against all major insect pests. Grass grub is only affected by Barrier U2 and it is not yet known if this endophyte also affects some of its relatives, such as Manuka beetle and Tasmanian grass grub.

In reality, what happens on each farm is influenced by several stress factors, including seasonal weather conditions (particularly drought), the size of insect populations and the type of damage they do, soil fertility and grazing management.

When more stress factors occur simultaneously, the combined pressure has a greater impact on pasture performance and therefore livestock productivity. These will vary throughout the country and between years (and even between paddocks) but it is reasonably certain that pests will limit productivity somewhere on-farm, at some point.

Ensuring there is endophyte-mediated protection against damage by insect pests in pasture (for example root aphid and black beetle) will enable pasture to withstand moderate populations of other pests such as grass grub, and will limit the effects of drought. Therefore, having a pasture highly infected with an effective endophyte has benefits beyond protection from a single pest. Nevertheless, this is no guarantee of long-term persistence.

Dairy cows and beef cattle performance by endophyte type

The ratings in the following table are indicative. Animal health and performance can vary under different management systems and between seasons.

Table 1

	AR1	NEA2	AR37	U2	Standard Endophyte	Without Endophyte
Freedom from ryegrass staggers	++++	++++	++++2	++++	++1	++++
Animal production	++++	Not tested	++++3	++++	+++1	++++

Sheep and lamb performance by endophyte type

Table 2

	AR1	NEA2	AR37	U2	Standard Endophyte	Without Endophyte
Freedom from ryegrass staggers	++++	++++	+++2	++++	++1	++++
Animal production	++++	++++	++++3	++++	++1	++++

Key to tables

++ Moderate animal production and health: This endophyte is known to regularly cause significant problems.
+++ Good animal production and health: This endophyte can cause problems from time to time.
++++ Very good animal production and health.

Notes on Table 1
Standard endophyte can cause ryegrass staggers, and has been shown to depress milksolids (MS) production through summer and autumn.
While ryegrass staggers has not been observed on cattle and dairy cows, it could occur on rare occasions.
In dairy trials overall MS production from ryegrass containing AR37 endophyte is not significantly different from that with AR1. A small reduction in MS was observed over summer on ryegrass containing AR37. A contributing factor to this was the lower clover content in AR37 pastures.

Notes on Table 2
Standard endophyte can cause severe ryegrass staggers, can significantly decrease lamb growth rates in summer and autumn, and significantly increase dags.
Ryegrass containing AR37 endophyte can cause severe ryegrass staggers, but the frequency of ryegrass staggers is much lower than for ryegrass with Standard endophyte. One50 AR37 may give rise to higher instances of ryegrass staggers than other AR37 cultivars in some situations.
Lambs grazing ryegrass containing AR37 endophyte can have reduced LWG during periods of severe staggers.

Influence of plant genetics

When choosing an endophyte, another factor to consider is the ryegrass genetics needed to deliver endophyte to paddocks. Cultivars of ryegrass vary in seasonal and annual dry matter productivity and persistence. An overlay of endophyte strains further complicates the array of options farmers have. In addition, not all endophytes are available in all cultivars.

To help decipher the matrix of cultivars and endophytes, the DairyNZ Forage Value Index (FVI – dairynz.co.nz/fvi) provides data on the agronomic performance of ryegrass cultivars with the various endophytes.

From this, farmers can identify good combinations of plant and endophyte genetics based on data from agronomic trials. Using the Cultivar Selector Tool within FVI, farmers can filter results for their farm by region, forage type, endophyte, ploidy and heading dates. Economic values are also calculated for each region.

For the Upper North Island, the Cultivar Selector Tool guides users automatically to AR37 and NEA2 as the most appropriate endophytes for reducing damage by black beetle. The option still exists to select other endophytes, which may be a rational choice as not all soils have damaging numbers of black beetle. Something to be aware of is that some endophytes are less effective in tetraploids and short-term ryegrasses than in diploid perennials, and this is reflected in a separate Endophyte Ratings Table.

Short-term ryegrasses that are often endophyte-free provide great feed for livestock over the winter months but also help feed insect pests, thereby improving their survival. To get the most out of endophytes, it is important to establish a dense pasture which will resist invasion of weedy grasses such as poa and the summer-active grasses.

These weedy grasses provide an alternative food source for adult black beetle, in particular, that will lay eggs which develop into damaging root-feeding larvae. Apart from Barrier U2, the available endophytes have no effect on these larvae.

Delivery of endophyte through seed

Endophyte is unable to spread from one plant to another. Instead, it spreads by colonising seed when endophyte-infected plants become reproductive in late spring. Harvested ryegrass seed is therefore the only practical way endophyte can be delivered to farmers.

Unfortunately, the rate of endophyte transmission to seed is imperfect. This is certainly the case for selected endophytes inserted into new cultivars, while the standard endophyte is more robust with relatively high rates of transmission. Differences also

Enhanced pasture persistence due to AR37 endophyte infection compared to without endophyte (WE) in early March 2008, three years after sowing at DairyNZ, Scott Farm, Waikato.

exist across the range of selected endophytes, with transmission of the AR1 strain generally being the best of the selected endophytes. Given this situation, the seed industry has an agreed minimum standard of 70% viable endophyte in a seed lot to ensure effective protection at a paddock scale.

Since the endophyte discoveries in the 1980s, New Zealand's grass seed industry has become highly experienced at managing seed production, seed cleaning and 'just in time' delivery to retailers to provide the best levels of live endophyte that are practical at a commercial scale. The temperature and relative humidity in which seed is stored are critical for endophyte, as it dies at a faster rate than the seed itself.

Endophyte-infected seed is therefore treated as a perishable product at all stages in the seed production and supply chain – this typically involves seed storage at low temperature (2-5°C) and relative humidity (30-40%). This equally applies once seed is delivered on-farm. Farmers and contractors should store seed in a cool and dry location, sow as soon as practical, and not carry seed over to a following season or year.

It's important to note that endophytes provide little protection for young seedlings in the first six weeks of growth. During this vulnerable stage, protecting your investment in endophyte-infected seed by using a seed coating will reduce the chance of damage as the endophyte begins to grow from the seed into the seedling and become metabolically active. Finally, farmers should buy from reputable sources and ensure seed is certified with a recent viable endophyte test.

The future

Developers of selected endophytes are seeking to extend the breadth and strength of control that endophytes can provide when it comes to pest protection. Of equal importance is no or negligible negative effects on livestock. To achieve this, endophytes beyond those found naturally within ryegrass are being researched.

When endophytes are transferred between grass species, the new combinations generally have poor compatibility. This requires plant breeders to select the right ryegrass genetics to enable synchronised endophyte growth within the new ryegrass host, particularly for transmission of endophyte to seed and survival in stored seed. In addition, the expression of endophyte chemistry must be sufficient to deliver pest protection.

Resources

- Agpest.co.nz
- Dairynz.co.nz/cultivar-selector
- Dairynz.co.nz/endophyte
- Dairynz.co.nz/FVI

Further reading

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Winning against weeds and pests in first year pasture

To maximise return on pasture renewal, weeds and pests must be controlled, as both can seriously reduce pasture establishment, production and persistence. It's worthwhile taking time to plan a pasture renewal process so the risk of weed invasion and pest damage are minimised.

Katherine Tozer, Trevor James, Alison Popay,
AgResearch

Weeds can:

- reduce the growth of desirable pasture species
- compromise animal health and welfare (e.g. giant buttercup is toxic to livestock and mouth ulceration can occur if large quantities of dry seed heads of yellow bristle grass are consumed)
- cause milk taint (e.g. pennyroyal)
- provide pasture pests with a food source (e.g. paspalum for black beetle)
- lead to grazing avoidance near the weed (e.g. Californian thistle)
- interfere with the sale of homegrown feed (e.g. yellow bristle grass in maize silage).

Weed seeds made up 98% of the total seeds from seedbanks sampled in spring in Waikato, Bay of Plenty and Taranaki[1] dairy pastures. Given the huge weed seedbank, it is not surprising 65% of total pasture dry matter was weeds in four to six-year old Waikato dairy pastures[2].

So what can you do about it?

Key findings

- Up to 98% of the total seed bank can be weed seeds. Weeds can affect pasture performance and animal health.
- Reduce weed and pest damage by including a control strategy in the pasture renewal plan.
- Control weeds in the 12-18 months before sowing by using strong herbicides or annual forage crops.
- Choose pasture species and endophytes based on the insect pests present, and use insecticide-treated seed to protect pastures for the first six weeks.
- Use softer herbicides in new pastures for the first six weeks if there is clover present.
- Sowing in autumn allows new pastures to establish before summer-growing weeds germinate.

Pre-establishment

Pasture renewal planning should begin 12-18 months before sowing and should include a weed and pest management strategy.

Weeds are divided into two categories: perennial weeds (docks, penny royal, Californian thistle, paspalum etc.) and annuals (hairy buttercup, summer grasses, chickweed etc.). Perennial weeds are very difficult to control in new pasture and should be managed using the Programmed Approach[3]. The Programmed Approach is information compiled from field practitioners and scientists, outlining the factors that contribute to successful regrassing programmes. This approach requires controlling pasture weeds for 12-18 months before sowing by:

- using strong herbicides such as dicamba and aminopyralid, which would be too damaging to new pasture. This method is most effective for broadleaf weeds such as docks, thistles and ragwort[4,5].
- planting an annual crop before sowing the new pasture, which is the best way to control grass weeds that cannot be controlled in a new pasture. To control perennial grass weeds such as paspalum, glyphosate can be applied both pre and post-cropping. To control annual grass weeds such as the summer grasses, applying herbicide to a summer crop can reduce weed seed entering the soil seedbank and germinating in the newly-sown pasture. It is important to select a crop that allows control of the weeds present.

Summer-active grasses (e.g. yellow bristle grass, summer grass, crowfoot grass) can be more productive than ryegrass and other desirable pasture species in dry and hot summers. Once grazed, they can produce new seed heads within four weeks[6]. These seeds can survive passage through a cow and be spread in effluent[7]. Several tools are available to reduce the spread of summer active grasses:

1. Fenoxaprop gives effective grass weed control but needs to be applied seven days after grazing to ensure sufficient leaf material has regrown to take up the herbicide[8]. A 28-day withholding from grazing period must be observed so there is no danger of herbicide residues in milk. Note: this herbicide does not provide any residual control, so any summer grasses that emerge after application will not be killed. Delaying fenoxaprop use is not an option as it is only effective when plants are small[8].
2. Seeds of yellow bristle grass and other summer-active grasses will not survive in wrapped bailage or silage if properly wrapped, and if they remained wrapped for at least seven days before being opened.
3. Maintain a vigorous sward using fertiliser and best practice grazing guidelines, including target residuals of 4-5 cm height (1500 kg DM/ha). Grazing lower than this affects pasture regrowth and can 'open up' pasture for weed ingress.

In some cases, mixed pastures have improved herbage production (particularly in climatic extremes) and reduced weed incursion[9]. However, a recent study in intensive Waikato dairy pastures[10] found increasing the number and type of sown pasture species had little effect on weed incursion entry.

Weed incursion occurred in all six pasture types compared (ryegrass and tall fescue-based pastures sown with legumes; legumes and forage herbs; legumes, forage herbs and other grasses).

It was concluded that pasture management is more important in determining weed abundance in most dairy pastures. Generally, the more complex the pasture mix, the more difficult it is to control weeds in the new pasture, emphasising the importance of planning and the Programmed Approach.

Clover complicates control of broadleaf weeds in new pasture as only softer herbicides can be used. Although effective, the target weeds must be small when softer herbicides are used as they become tolerant to these herbicides as they grow[11].

Broad-leaved dock

Yellow bristle grass

To manage broadleaf weeds, the traditional MCPB and 2,4-DB remain the mainstay although small amounts of MCPA are now formulated with MCPB for greater efficacy. Other herbicides used to target specific weeds without harming new pasture include bentazone, flumetsulam (individually or in a mixture) and bentazone/MCPB mixtures (Table 1).

There is limited opportunity to control grass weeds in new pasture so autumn sowing is advantageous, particularly in the Upper North Island. In autumn-sown pastures, summer-growing grass weeds such as yellow bristle grass, summer grass and crowfoot grass will not appear until late spring/early summer when the pasture is more mature and fenoxaprop may be used to control the summer grasses (as explained above).

In New Zealand the evolution of herbicide resistance is an increasing problem. Six pasture weed species (nodding and plumeless thistles, giant buttercup, Chilean needle grass, chickweed and ryegrass) are now resistant to one or more herbicides. If herbicide resistant weeds were present in the previous pasture or crop, then the Programmed Approach or a farm consultant can help farmers prevent their carryover into the new pasture.

Managing pests

When planning a new pasture, it is important to reduce pest pressure prior to and at establishment, and take a longer view than just the first year. Decisions on cropping prior to planting, sowing method, choice of pasture species and endophyte, use of treated seed and subsequent management are critical to a new pasture's successful establishment, productivity and persistence. Farmers will know what grass and clover cultivars best suit certain circumstances and what pests are likely to cause trouble. If in doubt, refer to DairyNZ's FVI Cultivar Selector Tool (dairynz.co.nz/cultivar-selector) and the Endophyte Ratings Tables (dairynz.co.nz/endophyte) and AgPest (agpest.co.nz) for information on the control and impact of key weeds and pests.

Going through a forage succession plan[12] before sowing a new pasture will help remove pests already present. The plan involves using a cropping regime (suggested in the Programmed Approach[3]) to reduce populations of pests, such as clover root weevil and nematodes, some diseases and weeds. This will help establish a vigorous pasture which should resist subsequent pest invasion, at least for a time, particularly if the ryegrass contains an appropriate endophyte.

Black beetle

The plan should also aim to reduce grass weeds in new pastures, as these compete with pasture and provide food for insect pests. For example, poa, paspalum and summer grasses are a good food source for black beetle and poa is also fed on by Argentine stem weevil. Grass weeds are a particular issue with black beetle, as most endophytes available to manage it deter the adult but have no effect on larvae. Therefore, having alternative grasses the adult can feed on is likely to increase the number of eggs laid, leading to a cycle of larval damage that will increase in subsequent years under favourable climatic conditions.

Be wary of using short-term ryegrasses to replace a runout pasture immediately before sowing a perennial pasture. These ryegrasses are particularly susceptible to Argentine stem weevil, one of the first pests to invade new pastures. Here, endophytes

Table 1. Herbicides that can be used in new pasture

Chemical	Trade names	Weed spectrum	Pasture stage	Weed stage	Rate/ha
2,4-DB	2,4-DB	Broadleafs	Legumes – 2 true leaves	Active growth	3-6 litres
Flumetsulam	Various	Broadleafs	Legumes – 4 true leaves	Seedling to 4 leaves	30-65 g
Flumetsulam (liquid)	Head Start	Broadleafs	Legumes – 2 true leaves	Seedling to 4 leaves	0.5-1.0 litre
Flumetsulam + benta-zone	Dynamo	Broadleafs	Legumes – 2 true leaves	Active growth	1.5-3.0 litres
MCPB	Various	Annual broadleafs	New	Active growth	3-4 litres
MCPB + MCPA	Various	Broadleafs	Legumes – 3 true leaves	Seedlings	Various
MCPB + bentazone	Pulsar, Quasar	Broadleafs	Legumes – 2 true leaves	4-6 leaf	5.0-7.5 litres
MCPB + MCPA + flumet-sulam	Tribal Gold	Broadleafs	Legumes – 2 true leaves	Active growth	4-5 litres

such as AR37 and Barrier U2 appear to provide more protection than AR1 and NEA2[13]. For further information on choosing a ryegrass/endophyte combination see the earlier article 'Unravelling the complexities of endophytes' in this *Technical Series.*

Also consider whether to direct drill seed or to cultivate first. Direct drilling is likely a better option to reduce risk of subsequent outbreaks of insect pests. Cultivation will damage insects such as grass grub or porina and reduce their numbers to near zero. However, having very low populations of pests at sowing, although good for establishment, can have long-term consequences for new pastures as populations of grass grub and porina are regulated by natural diseases which keep their populations below damaging levels.

When populations get very low because of cultivation, the disease inoculum in the soil is not renewed. This allows pest populations to increase and results in outbreaks two to four years after the new pasture is sown, causing severe damage and greatly reducing pasture performance and persistence[14]. Direct drilling will allow some survival of insects at establishment, continuing the turnover of diseases that will limit the increase in pest populations.

Endophytes will not provide strong protection of young seedlings from insect pests for the first six weeks after sowing. To protect an investment in pasture renewal, use seed treated with insecticide as an insurance. Different seed treatments are available depending on the insect pests present (e.g. black beetle, Argentine stem weevil or grass grub). For further information on the biology, control and impact of weeds and pests, visit agpest.co.nz.

Resources

- agpest.co.nz
- dairynz.co.nz/cultivar-selector
- dairynz.co.nz/endophyte
- grassland.org.nz (search the Programmed Approach)

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Fodder beet – friend or foe?

The rise of fodder beet popularity has seen the crop's sown area in New Zealand increase from about 100 ha in 2006 to 15,000 ha in 2014[1], and 75,000 ha in 2016 (PGGW, pers. comm.).

Dawn Dalley, **DairyNZ**

More than 80% of cows in Southland and Canterbury consumed fodder beet at some period during the 2015-16 season (unpublished data), and it is grown in all major dairy regions in New Zealand. Although fodder beet has been fed to overseas dairy cows for decades[2,3,4,5], it normally comprises just a small proportion of the diet.

Initial fodder beet use in New Zealand was for over-wintering non-lactating cows, especially in the South Island, with relatively recent widespread feeding of fodder beet to lactating cows[6]. Fodder beet for non-lactating cows is traditionally grazed in situ, supplemented most commonly with either barley straw[1], pasture silage[7] or hay. In situ grazing of fodder beet by lactating cows is more likely to occur during autumn, with lifted fodder beet bulbs more common during spring feeding periods and to non-lactating cows in off-paddock facilities during winter.

The Forages for Reduced Nitrate Leaching Programme (FRNL) identified fodder beet as a high nutritive value, low N forage crop with potential to mitigate the impact of excessive dietary N typical of New Zealand ryegrass pasture (3-5 g/100g DM).

Key findings

- Fodder beet is low in nitrogen (N), so can reduce urinary N excretion and therefore risk of N leaching loss from urine patches.
- The recommended maximum percentage of DM intake from fodder beet is 40% (lactating) and 70% (non-lactating), due to risk of acidosis.
- Even at these rates, some cows may still experience adverse health because of individual variations in diet selection and susceptibility to acidosis.
- High levels of fodder beet in the diet also increases risk of N and amino acid deficiencies, and can impact milk composition.
- Maximising production and environmental benefits of fodder beet, while minimising any negative impacts, requires careful management.

This is particularly so in late lactation and winter when the risks of nitrate leaching[8] and nitrous oxide emissions[9] in subsequent months is high.

As the proportion of fodder beet in the diet, and total diet composition, differs from overseas experiences, it is important to investigate fodder beet's role in animal performance, N excretion and animal health to inform best practice management for pasture-based systems.

The following information is the FRNL programme's results to date.

Nitrogen balance and rumen function

Two metabolism stall experiments measured the N balance, with lactating and non-lactating cows offered increasing proportions of the diet as fodder beet, with the remainder comprising either pasture (lactating) or barley straw and pasture silage (non-lactating).

The lactating cow experiment explored the impact of substituting 0, 20, 40 and 60% of ryegrass with fodder beet for cows fed ad libitum in late lactation. It became apparent that a diet of 60% fodder beet was detrimental to cow health, as 50% of cows developed acidosis despite implementing recommended transition management.

Based on this early finding, the fodder beet allocation was reduced to, on average, 23 and 45% of DM intake during the trial. Substitution of ryegrass with fodder beet did not affect feed DM intakes (Table 1) or milk yield (10.7kg/cow/d), microbial synthesis (129 g of N/d) or fractional outflow rates of digesta (0.16/h; 11.2 L/h).

Feeding 23 or 45% fodder beet in late lactation reduced nitrogen intake by 12 and 31%, respectively, with associated reductions in urinary N excretion of 25 and 45% respectively. However, acidosis risk increased when fodder beet was above 40% of the diet DM.

The interest in reducing N intake to reduce N excretion to the environment must also consider the overall N economy of the ruminant. Non-lactating cows offered 85% fodder beet and 15% barley straw excreted more N (22 g/cow/day) than they consumed, indicating that at 7.1% crude protein (CP), the diet was N deficient.

This N deficiency was mitigated by offering 70% fodder beet and 30% pasture silage (0.3 g N/cow/day gain; 10.9% diet CP). Rumen microbial growth was especially low in cows fed the straw compared with the silage diet (Table 1) and ammonia was undetectable in the rumen of cows fed the straw diet over much of the day. In addition, the proportions of the amino acids arginine, citrulline and ornithine decreased, while the proportion of glycine increased, when 23 or 45% fodder beet was included in the diet[10].

While researchers could not identify the underlying causes of the amino acid concentration changes, the results show that feeding fodder beet changes the cow's N economy, with potential impacts on cow health and production. The causes of the changes and the long-term consequences require further investigation if significant proportions of fodder beet are going to be sustainable as an alternative feed to help mitigate N loss to the environment.

Contrary to expectations, there was a greater proportion of large particulate DM (unable to pass a sieve with a 2 mm aperture) in cows fed fodder beet, than pasture alone. Saliva added during chewing helps buffer the rumen environment and maintain a stable rumen pH. The particle size results suggest changes in chewing behaviour with fodder beet diets which may be an important factor contributing to acidosis in some cows and not others. More research is required to investigate the intake rate and rumination patterns of cows consuming fodder beet.

In both the lactating and non-lactating cow experiments there were clear variations between individuals in their tolerance of

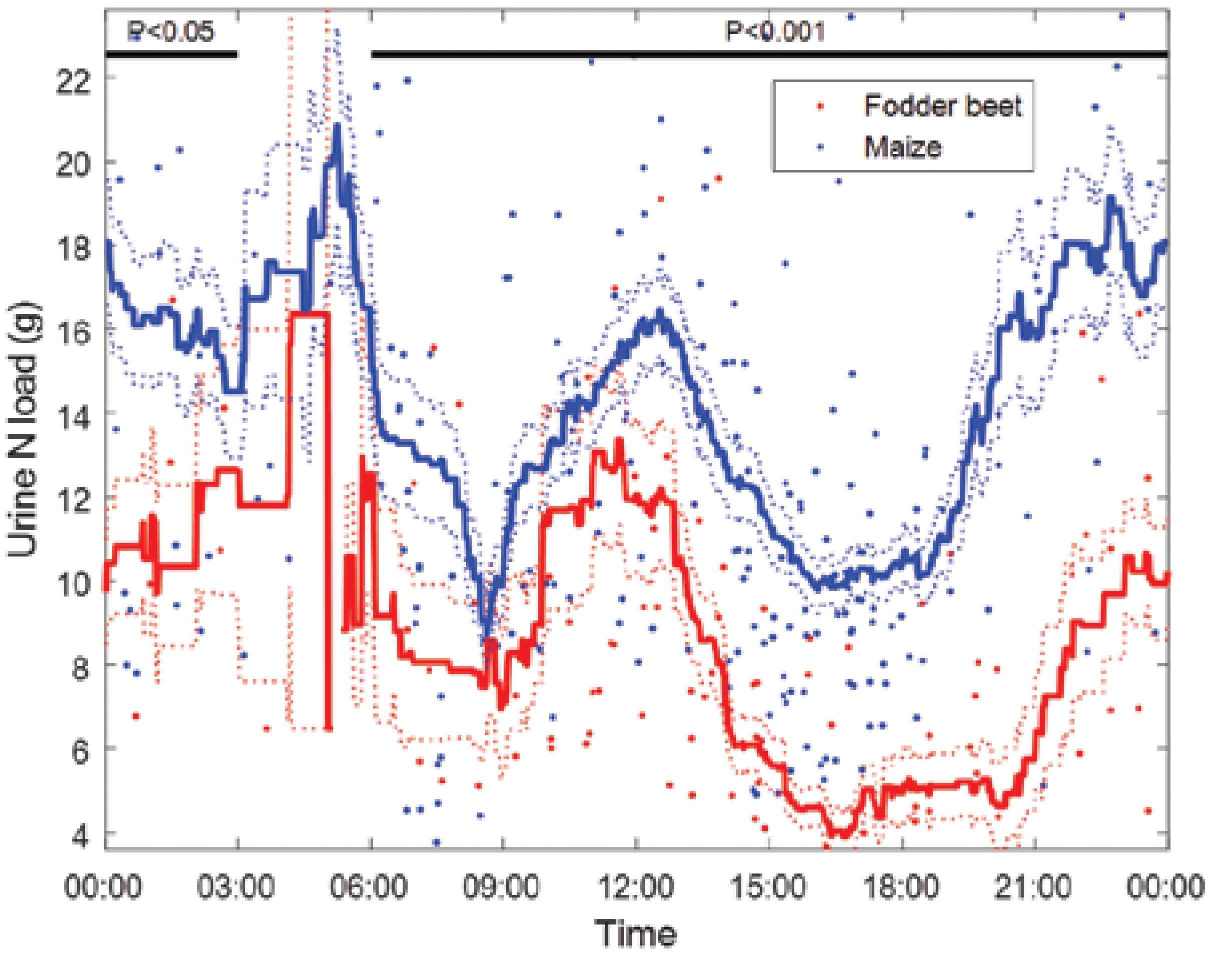
Table 1: Intake and nitrogen dynamics in lactating cows fed pasture, pasture with 23% fodder beet (23%FB) and pasture with 45% fodder beet (45%FB); and non-lactating cows fed fodder beet with 15% cereal straw (FB+Straw) or fodder beet with 30% pasture silage (FB+Silage) diets over a six-day period.

Chemical	Lactating				Non-lactating		
	Control	23%FB	45%FB	Significance	85%FB+Straw	70%FB+Silage	Significance
DMI	15.2	15.3	14.0	NS	6.4	8.3	NS
Water intake (l/cow/day)	29.4	16.8	12.3	***	4.0	17.0	***
N intake (g/cow/day)	460	407	317	***	74	144	***
Faecal N (g/cow/day)	148	139	131	NS	44	56	**
Milk N (g/cow/day)	57	64	67	NS	-	-	-
Urine N (g/cow/day)	205	155	112	***	52	87	**
Microbial N/kg DOMI (g)	15.5	13.7	12.2	**	6.6	15.8	***
Blood urea N at 7 am (mmol/l)	7.3	5.7	4.4	***	1.7	2.8	***

Table 2: Intake, milk production and composition and blood, urine, milk and faecal nitrogen concentrations of lactating cows grazing pasture and supplemented with either maize silage (control), 25% fodder beet (FB25) or 40% fodder beet (FB40) in autumn.

	Maize	FB25	FB40	Significance
Pasture intake (kg DM/day)	12.7	12.8	10.6	P<0.05
Maize silage intake (kg DM/day)	4	-	-	P<0.05
Fodder beet intake (kg DM/day)	-	4	5.7	P<0.05
Estimated ME intake MJ/day)	195	206	196	-
Estimated N intake (g/d)	520	530	460	-
Milk yield (L)	11.5	11.2	10.7	NS
Milk solids yield (kg)	1.02	1.10	0.98	P<0.001
Milk fat (%)	5.44	5.37	5.10	P<0.05
Milk protein (%)	3.99	4.31	4.34	P<0.05
Urinary N (%)	0.33	0.32	0.26	P<0.05
Faecal N (%)	2.4	2.6	2.5	P<0.1
Milk urea N (mmol/l)	4.8	5.2	3.9	P<0.1
Blood urea N (mmol/l)	5.2	5.2	3.9	P<0.001

Figure 1: The dynamic temporal changes in urine N load per urination event for non-lactating dairy cows offered pasture plus maize silage (Blue) or fodder beet plus pasture silage (Red). Solid lines denote a three-hour smoothing average and dotted lines denote SEM (standard error of the mean).



high proportions of fodder beet. Based on current research, 40% (lactating) and 70% (non-lactating) are the recommended upper limits of fodder beet in the diet to mitigate the risk of acidosis. However, even at these levels, variations between individuals in diet selection and susceptibility to acidosis are likely to have an adverse effect on some cows' health.

Milk production and composition, and nitrogen excretion

International research found cows fed pasture silage and concentrates did not produce more milk when supplemented with up to 4 kg DM/cow/day of fodder beet. However, increases in the milk fat and milk protein content resulted in significant increases in milk solids production[3,4].

FRNL researchers offered 25% (4 kg DM; FB25) or 40% (6 kg DM; FB40) fodder beet to cows in late lactation, grazing perennial ryegrass-based pastures, and compared this to cows offered pasture plus 4 kg DM maize silage/day (Maize).

Refusals were observed when cows were offered 6 kg DM fodder beet, such that the average intake was 5.7 kg DM/day (Table 2). Milk yield did not differ between the treatments, though the FB25 cows produced significantly more milk solids.

Although FB40 significantly increased milk protein content, milksolids was not affected as milk fat content was reduced. These cows also had an increased proportion of short chain fatty acids in their milk. Although clinical acidosis was not observed after the 18-day adaptation period, behavioural observations of FB40 cows suggested this allocation was at the upper limit of fodder beet intake and that some cows may have been experiencing subclinical acidosis.

Urinary, milk and blood N concentrations did not differ between the Maize and FB25 diets but were reduced in the FB40 cows. The reduction in urinary N concentration with the FB40 was associated with a lower N intake compared with the Maize and FB25 treatments.

Diurnal variation in urinary N excretion

To investigate the impact of fodder beet feeding on urinary N excretion, a 28-day early winter grazing study was conducted with non-lactating cows offered either pasture (8kg DM) plus maize silage (4kg DM) (Control) or fodder beet (8kg DM) plus pasture silage (4 kg DM) (FB).

The amount of urine-N excreted per urination was significantly lower from cows consuming the fodder beet diet, compared to the control (8.3 vs. 13.3 g N per event). This was largely due to differences in feed N intake (203 vs 339 gN/day), which led to a lower daily urine-N excretion by the fodder beet cows relative to Control (90 vs. 173 g N/cow/day, respectively). Diurnal trends in urinary N concentration and load differed between treatments (Figure 1) and cows consuming fodder beet had more, smaller urination events per day compared with the Control.

Conclusions

With a long shelf life, either in the ground or harvested, high yield potential, high digestibility and low nitrogen (N) content in the bulb, fodder beet offers many advantages. However, although fodder beet can reduce nitrogen intake and subsequently urinary N excretion, diets too low in nitrogen can have negative effects on animal performance.

The high sugar content requires careful transitioning onto fodder beet for good animal health outcomes. Changes in rumen fermentation influence milk composition, requiring caution with the amount offered to lactating dairy cows. Maximising the production and environmental benefits that fodder beet offers, while minimising any negative impacts on animal health, remains a research priority for the dairy industry.

Acknowledgement

Research was completed as part of the Forages for Reduced Nitrate Leaching programme, with principal funding from the New Zealand Ministry of Business, Innovation and Employment. The programme is a partnership between DairyNZ Ltd, AgResearch, Plant & Food Research, Lincoln University, Foundation for Arable Research and Landcare Research

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Science snapshot

Achieving target BCS at calving is important, how you get it is not![1]

For decades, we've known that getting cows to a body condition score (BCS) of 5.0 at calving is important and that there are health and reproduction advantages to ensuring that rising two and three-year-old animals are BCS 5.5.

Recently, some farm advisors have claimed there is a difference between BCS gained quickly in the autumn, when the cow is not lactating, and that gained slowly through late lactation and the dry period, usually by feeding supplements and pasture.

They claim that slow BCS gain is better for the cow, results in less metabolic disease around calving, and the cow loses less BCS in early lactation. Yet no basis exists for this recommendation, for pasture-based systems.

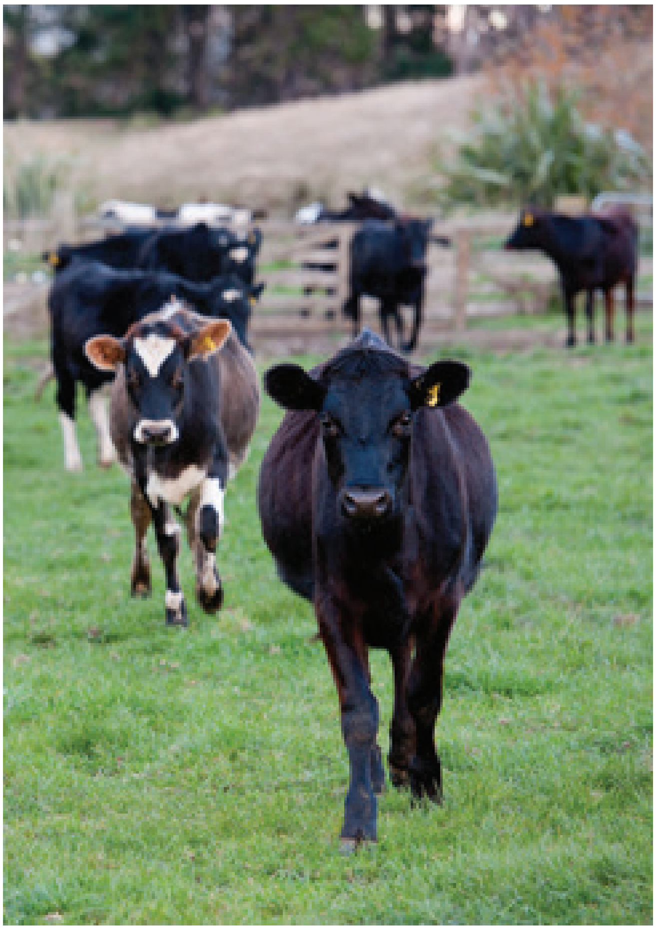
We investigated the effect of timing of BCS gain by managing feeding and milking frequency in late lactation to achieve two herds of cows:

- Herd One had a BCS 5.0 at dry-off in early May and only gained 0.25 BCS units after drying off
- Herd Two had a BCS 4.25 at dry-off in early May and had to gain a full BCS unit in the next 30 days.

There was no effect of BCS gain strategy on milk production in the following lactation. There were very small differences in blood metabolic markers. The metabolic effects suggest the cows that dried off thinner and gained BCS quickly lost less BCS in early lactation and were more healthy than the cows that gained BCS slowly during late lactation and when dry. However, these effects were small.

The results from this study are very clear. The traditional New Zealand-style system of gaining BCS rapidly after cows are dried off does not negatively affect their production or health after calving and does not result in greater BCS loss in early lactation.

Achieving BCS target for young (BCS 5.5) and mature (BCS 5.0) cows optimises milk production and reproduction, and minimises the risk of metabolic (e.g. milk fever, ketosis) and infectious (e.g. mastitis and metritis) diseases after calving. The strategy for getting cows to target BCS is not important, but requires a detailed feed budget and for cows to have sufficient time dry to achieve the necessary BCS gain.



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