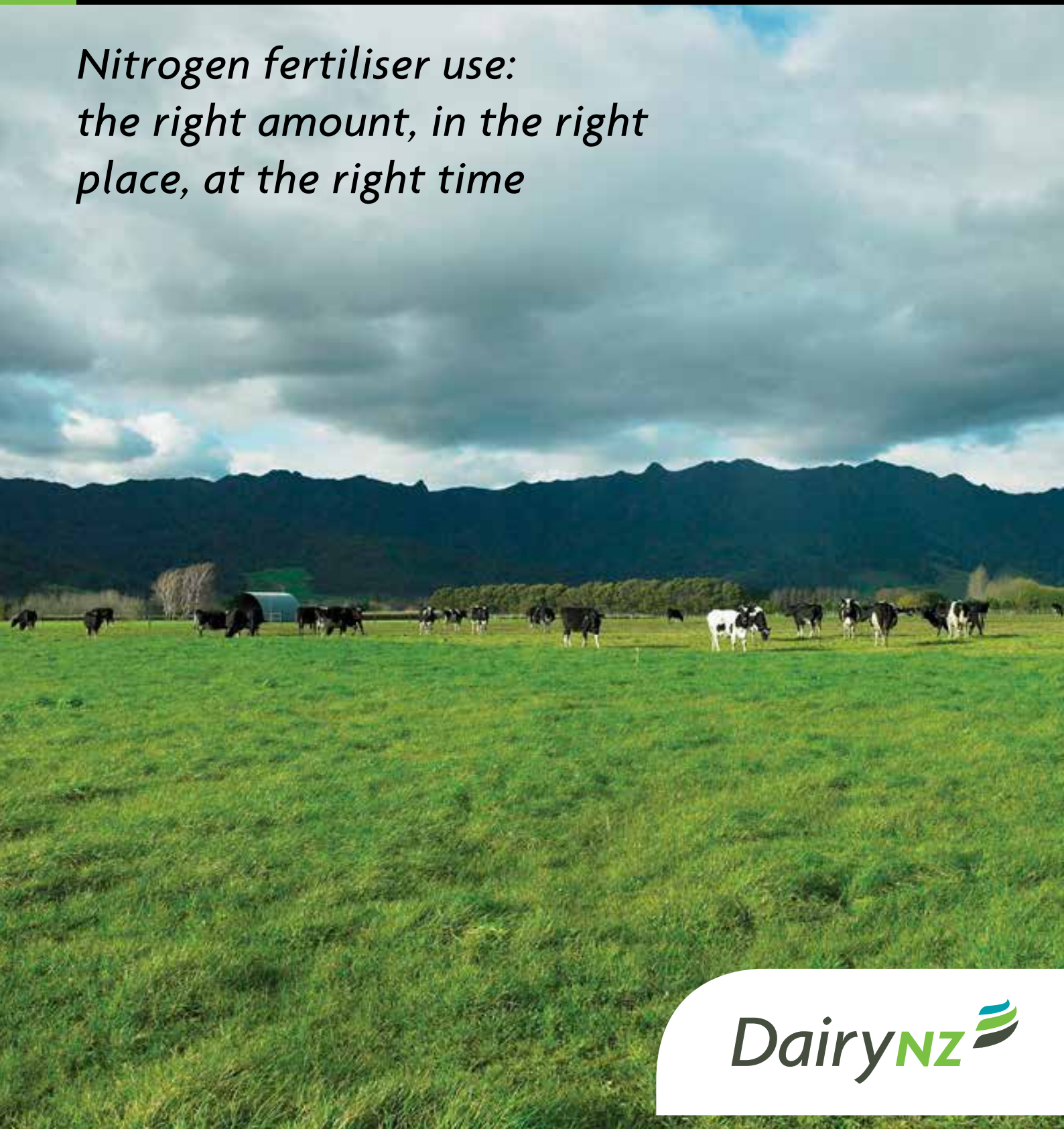


# Technical Series

IN BRIEF

*Nitrogen fertiliser use:  
the right amount, in the right  
place, at the right time*



DairyNZ 

# Contents

## 1 Nitrogen fertiliser use: the right amount, in the right place, at the right time

Nitrogen (N) fertiliser is a handy strategic and tactical tool for increasing feed supply to match animal demand, yet it must be managed carefully to maximise dry matter production (response) while minimising potential losses.

## 7 Looking after your soil carbon – what are the benefits?

Carbon makes up about half the mass of soil organic matter and many soils in New Zealand can contain more than 100 tonnes of carbon per hectare in the top metre. Should we protect this organic matter, along with the carbon it holds, and do we know how?

## 11 Making a success of full-season once-a-day milking

Milking is a time-consuming task, typically accounting for over half of labour hours used on New Zealand dairy farms. Reducing the number of milkings potentially decreases the number of hours worked, or allows that time to be used for other tasks.

## 14 Science snapshot

Since the release of the New Zealand Government's National Policy Statement for Freshwater Management in 2011, our grazing systems have experienced increased scrutiny with regards to their environmental impact.



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# Nitrogen fertiliser use: the right amount, in the right place, at the right time

Fertilising pasture with nitrogen is a balancing act - an art, but with plenty of science behind it.



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Nitrogen (N) fertiliser is a handy strategic and tactical tool for increasing feed supply to match animal demand, yet it must be managed carefully to maximise dry matter production (response) while minimising potential losses. Here, we explore the decision-making required for the optimum use of nitrogen and what drives N losses into the environment.

## Cost-effective use of N fertiliser: five key questions

When deciding on N fertiliser applications, there are five important questions to ask and each has a range of factors within that will influence the response (Box 1). This demonstrates the complexity of the decision-making but, in essence, it is simply about ensuring the 'right amount, in the right place, at the right time', for example that N fertiliser is only applied when other factors are not limiting pasture growth and it is economically sound to do so based on the cost of growing the extra pasture relative to milk price.

## Key points

- Ask yourself five key questions when considering your nitrogen fertiliser application programme for the season (Box 1).
- A "less N" fertiliser policy growing less grass can match "high N" fertiliser programmes in profitability, with adjustments, but choosing alternative feed sources to replace the fertiliser will also mean N is still imported into the farm, and leached out.
- If conditions are unfavourable for N fertiliser application, pasture response will be slow and small.
- High organic matter soils have more N in-situ, so pastures on lower organic matter parts of the farm may result in more kg DM per unit N applied.
- N fertiliser application rates of 20-50 kg N/ha combined with good pasture management will not impact significantly upon clover productivity.
- Individual N applications up to 50 kg N/ha achieve the best dry matter response (kg DM/kg N), in good conditions.
- There is a risk that losses of N from the farm system increase disproportionately to the amount applied beyond 200 kg N/ha/year.



## Box 1: Key decision points for individual N applications

The question	The decision is based on...
<b>1. Do I need extra feed?</b>	Identified deficit using: <ul style="list-style-type: none"> <li>• Feed budget</li> <li>• Feed wedge</li> </ul>
<b>2. Is the paddock likely to respond to N?</b>	Answer yes to ALL of these: <ul style="list-style-type: none"> <li>• Time of year OK?</li> <li>• Adequate soil moisture and temperature?</li> <li>• Soil fertility OK?</li> <li>• No farm dairy effluent recently?</li> </ul>
<b>3. What is my expected size of response?</b>	Consider the following: <ul style="list-style-type: none"> <li>• Season - soil moisture and temperature</li> <li>• Paddock potential</li> <li>• Clover content</li> <li>• Weather</li> <li>• Soil fertility</li> </ul>
<b>4. How much N and what type?</b>	Depends on: <ul style="list-style-type: none"> <li>• Growing conditions/season</li> <li>• Risk of loss – volatilisation or leaching</li> <li>• Price per kg N</li> <li>• Expected agronomic effect (Q3)</li> <li>• Able to mix with other fertilisers?</li> </ul>
<b>5. Are conditions OK for spreading N?</b>	Consider the following: <ul style="list-style-type: none"> <li>• Slope OK?</li> <li>• Ground conditions OK?</li> <li>• Weather forecast – not heavy rain?</li> <li>• Wind – not too strong or in the wrong direction?</li> </ul>

### 1. Do I need the feed? Tactical and strategic decisions

Fertiliser is used to boost pasture covers to fill anticipated feed shortages; a tactical approach to N fertiliser usage for supporting the overall farm strategy. Variations in weather during the year requires thinking on your feet, anticipating potential feed shortages, e.g. estimating depth and expected duration of a deficit, and whether it is possible to manage through a short-term deficit. If not, then it is a choice between imported feed or N fertiliser; if N fertiliser is the choice, then the next set of questions covered in the following sections become critical: will the pasture respond to N and what is the likely size of response (i.e. will it overcome my shortage)? Of course, the challenge is then ensuring it is applied early enough (in advance of) the feed deficit.

At a more strategic level, the system set-up determines the approximate annual amount of fertiliser N that will be required. Table 1 shows a few scenarios by way of example. It is possible to run a predominantly pasture-fed herd with nil N fertiliser input, but the system obviously has to operate on less grass eaten. For example, DairyNZ ran a nil N fertiliser system for 10 years, with an average grass production of 15.8 t DM/ha (2.56 cows/ha) compared with 18.7 t DM/ha (3.06 cows/ha) in a system receiving 180 kg N/ha per year<sup>1</sup>. A second example demonstrates two contrasting strategies to achieve the same production in the Pastoral 21 (P21) Waikato farmlet study: c. 150 kg N/ha (3.2 cows/ha) vs 50-90 kg N/ha (2.6 cows/ha)<sup>2</sup>.

The comparative profitability of the two studies is interesting. Separately, both studies showed a higher profitability for the higher input system at high payout and lower profitability at low payout. For example, in Study 1<sup>1</sup>, the 'switch point' in these particular farmlets was around \$5.10 per kg MS: above this, the higher N system was more profitable, and below this, the nil-N system won. Interestingly, \$5.10 per kg MS was only exceeded in 3 out of the 10 years of the study.

Comparisons within the two studies demonstrate some of the principles of N cycling:

- A 14-15% decrease in estimated N surplus (kg N/ha) at lower N inputs, indicative of a decrease in N return through animal excreta (urine and dung)
- Measurements of N leaching showed reductions in both studies
- No significant effect over the whole year of differing N rates on pasture protein contents (or ME)
- More protein eaten per ha at higher N rates
- A relatively small proportion of N removed in milk.

Lowering N surplus and therefore N leaching by using less N fertiliser and growing less pasture can match the profitability of higher N input, with appropriate adjustments for less pasture growth. Choosing another feed source to replace lost pasture still means that N is imported onto the farm and will contribute to leaching. Fertiliser per se is not the issue; it is amount of protein eaten (pasture AND supplementary feed).

## 2. Is the paddock likely to respond?

Soil temperature and moisture are the key drivers. A commonly accepted rule of thumb is to apply N only when the soil temperature is > 6°C. Too little or too much soil moisture can have a large effect on yields and N uptake. In the absence of irrigation, suitable conditions (and therefore profitable use) generally only occur between spring and early summer (before lack of soil moisture) and any use from late summer through autumn is higher risk, both environmentally and financially.

Nitrogen fertiliser is a growth multiplier. If conditions are unfavourable for growth, N fertiliser response will be small and slow. Pastures will also respond best to N when all other soil nutrient levels are satisfactory.

**Table 1.** Measurements from two farmlot studies, providing examples of different strategies for growing and utilising pasture. Note that we have estimated a 'N surplus' from the published data as an approximation of excretal returns (see text for details).

	Study 1 <sup>1</sup> (2001-2011)		Study 2 <sup>2</sup> (2011-2015)	
	Typical	Nil-N	Typical	Low N
<b>N fertiliser</b> (kg N/ha/year)	180	0	150	50-90
<b>Clover content of sward</b> (%)	7	15	8	11
<b>Pasture protein</b> (% , annual average)	20.1	20.3	21.1	20.2
<b>Pasture ME</b> (MJ/kg DM, annual average)	11.5	11.6	11.8	11.6
<b>Pasture grown</b> (t DM/ha)	18.7	15.8	16.9	15.4
<b>Pasture grown per cow</b>	6.2	6.2	5.2	5.9
<b>Stocking rate</b> (cow equivalents/ha)	3.1	2.6	3.2	2.6
<b>MS/cow</b>	371	392	369	444
<b>MS/ha</b>	1135	942	1193	1164
<b>Estimations based on the above data:</b>				
<b>A: N eaten</b> (kg N/ha) <sup>a</sup>	511	436	485	423
<b>B: N removed in milk</b> (kg N/ha)	79	66	84	81
<b>A-B: Surplus</b> (kg N/ha)	432	370	401	342
<b>% decrease</b>		<b>14</b>		<b>15</b>

<sup>a</sup> Assumes a pasture utilisation of 85%

### 3. Size of response?

The size of the response to N fertiliser will depend on the factors listed in Box 1. However, above all, season (i.e. growing conditions) was the greatest influence, affecting overall response to fertiliser N and the time to fully express this response (Table 2). Building up a bank of knowledge about one’s own farm over time is a useful management tool to refine these guidelines. Mineral N in Farm Dairy Effluent (FDE) applications will substitute for N fertiliser, as will N mineralised over time from the organic component of FDE.

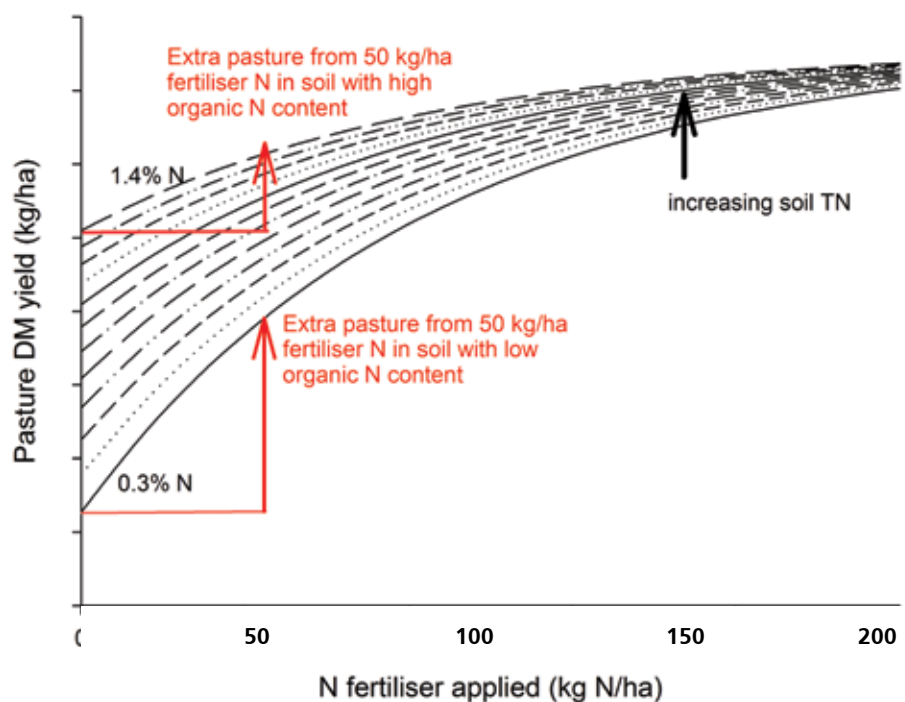
Nitrogen fertiliser interaction with clover is an interesting conundrum. For every 3 kg fertiliser N applied, N fixation by clover is reduced by about 1 kg N/ha/year<sup>3</sup>. Therefore, in legume-rich swards, N fertiliser use needs to be carefully considered. However, it has been reported that rates in the order of 20-50 kg N/ha per application, plus good grazing management that minimises the competitive effects of ryegrass, are unlikely to have a major effect on the yield of clover<sup>3</sup>.

Soils with high levels of organic matter have been found to have higher soil N supply, which means the pastures they support do not require as much N fertiliser. This suggests more DM per kg N applied may be achieved by targeting paddocks with lower soil organic matter (Figure 1).

**Table 2.** Typical pasture N response rates according to season, based on an expert synthesis of the available NZ pasture data <sup>4</sup>.

Season	Months	Time for full response (weeks)	Typical response (kg DM/kg N applied)
Late winter/early spring	July-Sep	5-6	10-15
Mid-spring	Oct-Nov	3-4	20
Summer	Dec-Feb	unpredictable	unpredictable
Autumn	Mar-Apr	6-8	5-10
Early winter	May-Jun	10-14	4-8

**Figure 1.** An example of the effect of soil total N (TN) on response to fertiliser N, assuming growing conditions are the same in both paddocks <sup>5</sup>.



#### 4. How much and what type of N?

Higher rates of N at individual applications generally result in less DM return per kg N applied. Figure 2 shows the typical shape of an N fertiliser response curve from yields measured in spring in the Waikato. Fertiliser efficiency (in kg DM/kg N applied) begins to decrease at rates above about 60 kg N/ha (depending on conditions), which supports the 50 kg N/ha upper limit per application recommended by many. While most of the response is usually seen in the first harvest, a small response occurs in the next regrowth phase; however, there is rarely a residual effect beyond the second harvest.

Fertiliser N losses can be reduced at times by matching the appropriate fertiliser to the prevailing soil moisture and weather conditions. Ammonium nitrate or sulphate of ammonia are less susceptible to volatilisation when applied during hot, dry conditions than urea and DAP (di-ammonium phosphate). Urease inhibitors can also decrease losses from urea in periods when loss is expected<sup>6</sup>.

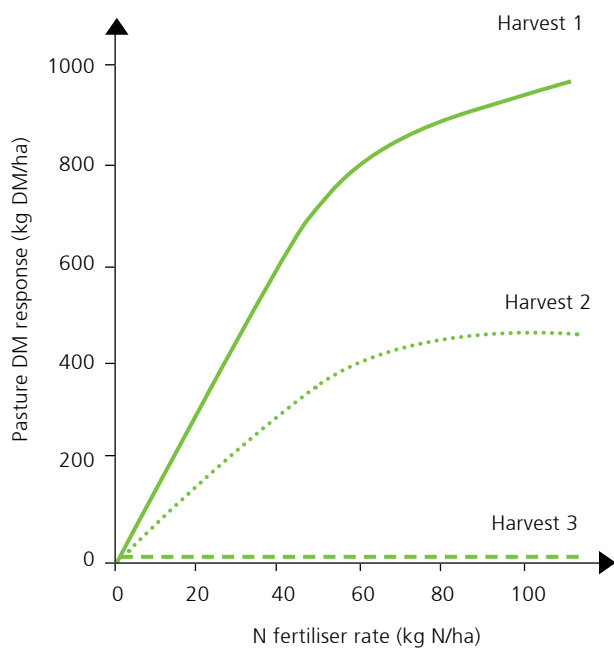
#### 5. Are conditions suitable for spreading N?

Box 1 summarises the key points; more detailed guidelines are available from the Fertiliser Association of New Zealand (FANZ)<sup>7</sup>. This is about making sure the fertiliser goes where it is meant to go (not directed/blown into ditches, surface waters and general non-productive areas) and stays there (does not run-off slopes when soils are too dry or too wet), as well as about applying only when the pasture can use it (right growing conditions). As FANZ says: spreading fertiliser to achieve these objectives is a technically demanding task. While some land managers spread some or all of their fertiliser themselves, spreading by Spreadmark accredited spreading companies is recommended.

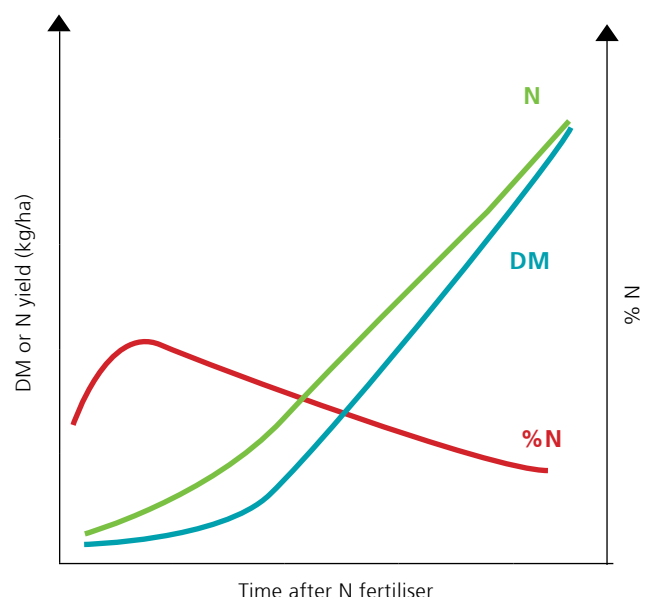
#### How does pasture respond to N fertiliser?

Pasture rapidly takes up fertiliser N, resulting in a high or 'luxury' N concentration before gradually declining or 'diluting' as dry matter accumulates (Figure 3). Pasture response to N is usually observed as an increase in the number and growth rate of tillers. The length of time between N application and grazing is a balancing act; on one hand, allowing enough time for pasture to use the fertiliser and, on the other, maintaining quality and minimising clover suppression by shading.

**Figure 2.** Example of an N response curve. Note the smaller carry-over response into a second harvest (grazing), and the almost linear N response up to around 50 kg N/ha.



**Figure 3.** Pasture dry matter accumulation following N fertiliser input, showing rapid uptake of N and dilution (reduced concentration) with time.

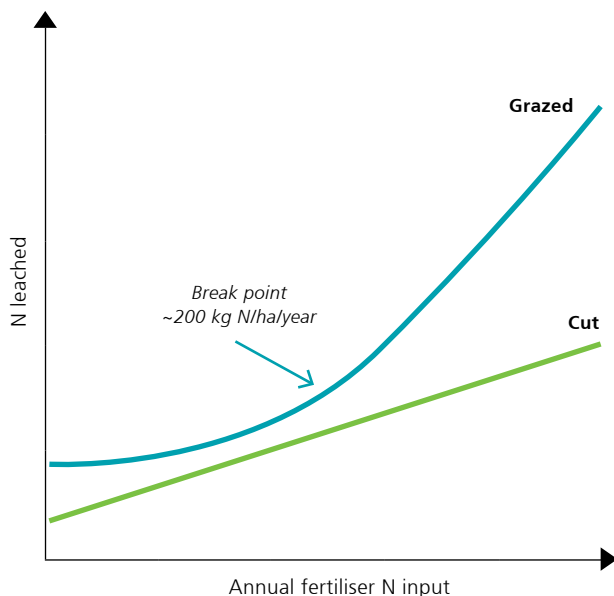


## How does N fertiliser contribute to N leaching losses in a grazed pasture system?

Nitrogen losses from fertilised grazed pasture increase with the N fertiliser rate, especially at higher rates. This 'breakpoint' above which N losses increase disproportionately with N fertiliser inputs is around 200 kg N/ha/year<sup>8</sup>. Compare this with generally smaller losses from fertilised cut and carry paddocks (Figure 4). This is because N fertiliser drives N leaching from a grazed pasture through the indirect effect of increasing herd N intake and excretion, resulting in more urinary N per hectare. Here's how it works: applying N fertiliser increases pasture DM production which increases the amount of pasture (and protein) eaten per hectare. Because only a small proportion of N is retained by the animal in milk or meat (15-30%), correspondingly more N is excreted back to the pasture in dung and urine. So the effect of fertiliser N on leaching risk is mainly via increased excretion (especially urine) rather than 'direct' leaching of fertiliser.

The effect of fertiliser on N leaching is mainly through the extra pasture grown and eaten rather than a large increase in its protein content. Of course, this assumes the right amount of fertiliser is applied at the right time, in the right place; otherwise direct loss of fertiliser can occur and can constitute up to 30% of losses to water.

**Figure 4:** N leaching with increasing annual fertiliser N input from grazed versus cut pasture. The breakpoint is where losses increase rapidly with N input.



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# Looking after your soil carbon - what are the benefits?

Carbon makes up about half the mass of soil organic matter and many soils in New Zealand can contain more than 100 tonnes of carbon per hectare in the top metre<sup>1</sup>. Should we protect this organic matter, along with the carbon it holds, and do we know how?



Louis Schipper, Dave Campbell and Aaron Wall,  
University of Waikato

## Soils and the carbon cycle

For centuries, farmers have been aware of the importance of organic matter in enhancing a number of key soil properties critical for supporting plant growth and other ecosystem services<sup>2</sup>. Organic matter has an important role in stabilising soil aggregates that contribute to structure allowing water and gases to pass into and through the profile<sup>3</sup>. Roots also penetrate more easily into well aggregated soils. Nutrients like nitrogen and phosphorus are bound and held in organic matter, which are slowly released during decomposition. Lastly, organic matter is a source of energy supporting much of below ground life.

In the last few decades, it has also become increasingly obvious that building soil organic matter can also remove carbon dioxide from the atmosphere. Globally the land is currently acting as a carbon sink removing some of the excess carbon dioxide from the atmosphere.

## Key findings

- Increasing or maintaining soil carbon in pastures provides dual benefits of improving soil health and reducing carbon dioxide in the atmosphere.
- Carbon inputs to farms include plant photosynthesis, imported feed and manures; while losses include plant and animal respiration, milk, animal and feed exports, and leaching.
- The balance of all these inputs and losses result in an overall increase or decrease in soil carbon and these can vary greatly between farms.
- One way to reduce carbon losses during pasture renewal is to minimise the time between pasture spray off and re-emergence of a new sward, particularly when soil moisture is high.

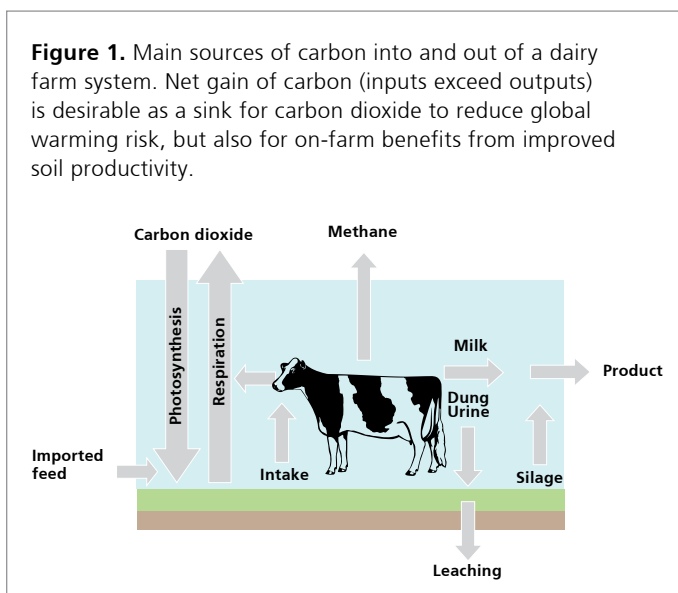
Very recently, there has been an international call to increase soil organic matter at global scales to further offset greenhouse gas emissions<sup>4</sup>.

### Carbon cycling on-farm

The overall increase or decrease in carbon for a farm is the result of generally small differences in total imports (gains) and exports (losses) of carbon (Figure 1). A growing pasture rapidly captures carbon dioxide from the air by photosynthesis. Much of this carbon is quickly released back to the atmosphere as plants respire or more slowly as microorganisms decompose dead plant material. Plants also release carbon from their roots, called exudates, which influence a broad range of microbial processes including nutrient cycling. Much of these exudates are also decomposed in soils. Grazing animals digest plant material, with the carbon either being released to the atmosphere (as carbon dioxide and methane), converted into products like milk and meat, or excreted in dung and urine. After these products are exported off-farm, the embodied carbon is later released to the atmosphere following consumption.

The overall change in carbon balance for each farm is the net effect of all the different carbon gains (plant growth, feed and manure imports) and losses (respiration, exports) caused by many interacting factors including annual weather patterns, soil type, and management practices<sup>5</sup>.

At the University of Waikato, we have made measurements of all these transfers of carbon for three different dairy farms (Figure 2) to estimate whether the farm gained or lost carbon<sup>6,7</sup>. These Waikato farms all varied in terms of their management with differing stocking rates and levels of manure and feed import.



An interesting example is farm C, which overall had a small gain in carbon. The large amount of carbon imported as feed (to support the higher stocking rate) was mainly lost through increased cow respiration and increased milk production.

Along with changes in management, the net carbon balance of farms can vary between small carbon gains or losses as part of natural year-to-year variability of weather. This natural variability needs to be taken into account when attempting to find management practices that manage soil carbon.

## Could New Zealand's soils be recognised as a carbon sink?

Kara Lok, DairyNZ

Globally, soils store significantly more carbon than trees and plants together. Certain management practices can either sequester carbon in soils or deplete and release carbon from the soil, with significant effects on net greenhouse gas emissions.

While at a national scale New Zealand soils have higher soil carbon levels than the world average, there appears to be little change in overall levels over time. This suggests there is limited potential for significant carbon sequestration from New Zealand's soils.

Soil carbon is hard to monitor and measure and while it takes a long time to build up, it tends to be lost very rapidly, through poor land management practices, wind erosion and droughts. For these reasons it is not accounted for in New Zealand's Greenhouse Gas Inventory or the international greenhouse gas reporting framework and is not considered a viable offsetting option at this point in time. New Zealand's inventory does, however, assume the carbon content of soil changes when the land use changes.

Ongoing research in New Zealand highlights the uncertainties with assessing soil carbon and the mechanisms of carbon cycling. Soil carbon has shown different trends in grazed flat land and hill country, but there is insufficient evidence to demonstrate a significant overall trend of soil carbon storage in New Zealand's pastoral land.

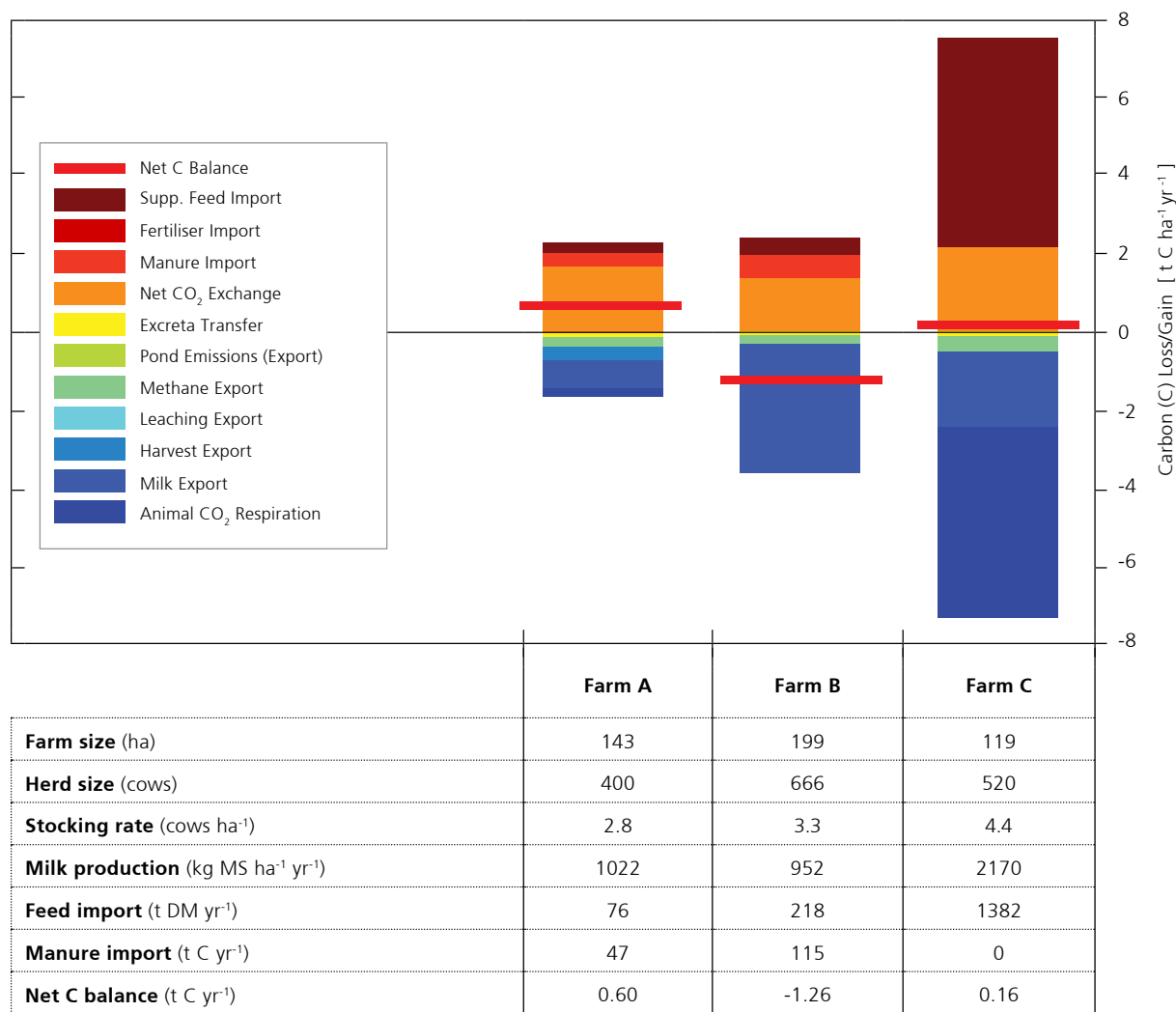
While the research indicates land management has a significant effect on soil carbon stock, showing that soil organic matter and soil carbon may be increased through a variety of methods, there is limited understanding of the mechanisms which drive these fluctuations. The practices which have been identified so far include minimising tillage, improving grassland management and restoration of degraded lands, and optimising grazing patterns.

Further research is required to verify the potential soil carbon gains and evaluate any possible adverse impacts or complimentary benefits from applying these practices in farm systems. Effective assessment methods for national level accounting would also be required if soil carbon was to become an effective mitigation option for the agricultural sector in the future.

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**Figure 2.** Measured flows of carbon in and out of 3 different farms in the Waikato. Values above the 0 line represents a gain of carbon and values below the line represent a loss of carbon. Manure is imported as a source of fertiliser from outside the farm. The net carbon balance is the overall effect of all gains and losses and designated by the horizontal red line and given in the table.



### Carbon loss during pasture renewal

One management practice we identified that resulted in soil carbon loss was pasture renewal. Pastures are renewed for a variety of reasons and there are several approaches to achieving these transitions including spraying to kill the existing sward, followed by direct drill or full cultivation to establish the new sward.

Following death of the old sward and before the establishment of the new sward, the soil remains bare without photosynthetic inputs of carbon. Meanwhile microorganisms in soil continue to produce carbon dioxide while degrading soil organic matter and the roots killed by herbicide. Across five different studies of pasture renewal events, we found that total soil carbon declined by 0.7 and 4 t C ha<sup>-1</sup> <sup>8</sup>. The amount lost depended on the time between pasture death and growth of the new pasture and the soil moisture at the time of renewal (Figure 3). Higher soil moisture resulted in greater microbial degradation of soil organic matter and dead roots. When soils were drier, microorganisms were limited by water availability and their activity decreased.

Losses of soil carbon were minimised when soils were dry, however pasture renewal could be risky during these conditions. Under all soil moisture contents, it is possible to reduce

carbon losses by minimising the time between death of the original pasture and establishment of the new pasture. In our experiments, this was achieved by reseeding using direct drilling without full cultivation. Our data would suggest any reduction in time to new pasture growth would be beneficial, particularly when soil moisture is high. For average soil moisture conditions, each additional day the soil is bare results in a 50 kg C ha<sup>-1</sup> loss.

### Ongoing and future work

We are now examining whether the harvesting of feed (e.g. maize) and/or importation of feed alters the carbon balance of pasture soils. Ordinarily, a paddock covered by pasture would be grazed and some of the carbon returned to the soil as manure. However, in the situation of a maize silage crop all harvested biomass (and subsequently carbon) is removed from the paddock. Additionally, two cultivation events are required – once for establishment of the maize crop and a second to return to pasture. Consequently, the result from the maize crop can be a large loss of carbon. We are currently trying to determine how big this loss might be and identify ways to decrease this carbon loss.

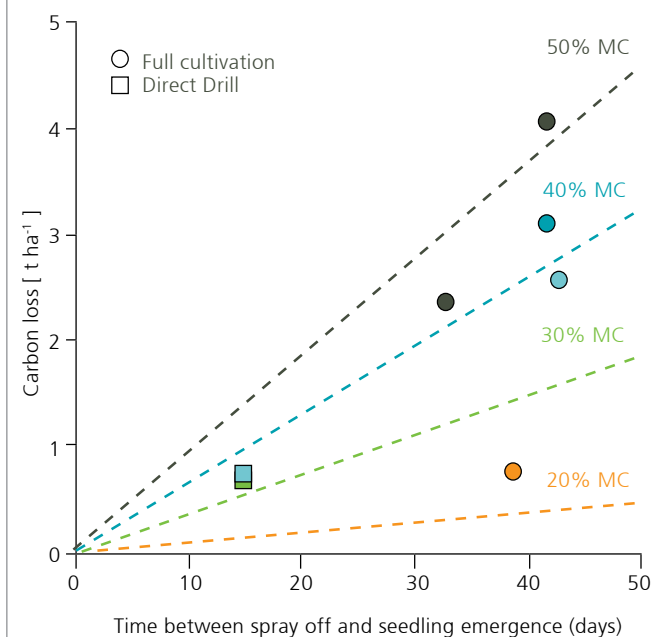
Conversely, when supplemental feed (e.g. the maize harvested in the above scenario) is supplied to the cows this represents an import of carbon. Carbon can be imported via wastage from any supplemental feed fed directly on the paddock, and increased excreta (or effluent) associated with the additional feed, all of which increase carbon inputs. We are attempting to determine whether feed imports result in an overall increase in soil carbon.

Overall, we are trying to answer the question of whether the movement of feed (or think of it as carbon) between paddocks or farms result in an overall gain or loss of soil carbon, and how might we manage the system better to minimise losses or maximise gains.

### Final thought

There is considerable interest about the need for long-term gain of soil carbon both internationally and in New Zealand. Maintaining or attempting to increase soil carbon generally arises from good farming practices. We have shown that maintaining a healthy sward and decreasing the time for pasture renewal, particularly when soils are wet, can decrease losses. The main benefit of looking after soil carbon is protection of soil health, such as maintaining soil structure and nutrient storage.

**Figure 3.** Cumulative losses of carbon between spraying of existing pasture and new sward establishment. Symbols are measurements from actual sites, dashed lines are predicted losses with time depending on soil moisture at time of renewal. Carbon losses were greatest when establishment of new pasture was delayed and when soils were wet.



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# Making a success of full-season once-a-day milking

Recently, there has been increased interest in the use of extended milking intervals, particularly full-season once-a-day (OAD) milking.

## Background

Milking is a time-consuming task, typically accounting for over half of labour hours used on New Zealand dairy farms<sup>1</sup>. Reducing the number of milkings potentially decreases the number of hours worked, or allows that time to be used for other tasks. It also provides more flexible working hours, increasing the attractiveness of dairying as a career and the pool of labour available through the use of part-time staff.

Data sourced from the Dairy Industry Good Animal Database (NZAEL) suggests that in 2015/16 only 53% of farmers milked their whole herd TAD (twice-a-day) for the full season, with the remainder using OAD part-season for all (19%) or part (16%) of their herds, or OAD full-season for all (9%) or part (3%) of their herds<sup>2</sup>. The 9% of farmers milking full-season OAD was up from 5% in 2014/15<sup>2</sup>. Tactical OAD milking may be used part-season on all or part of the herd in response to adverse conditions (e.g. summer drought, poor body condition or temporary labour shortages). Milking OAD full-season is a strategic decision which requires planning and an evaluation of the whole farm system. The purpose of this article is to summarise the milk production effect of full-season OAD from research and commercial herds and discuss their implications on the farm system and economics.



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## Key messages

- Full-season OAD (once-a-day) milking has been tested in only four controlled experiments and the context of these experiments should be considered when translating results to commercial farms.
- The decrease in farm milksolids production is likely to range between 6-16% in the first season, and appears to be related to breed and the level of milk production per cow.
- Costs equivalent to the value of the reduced milk production should be permanently reduced from the business if wanting to maintain or improve profitability.
- Case studies have indicated the required level of cost savings can be achieved.
- If the target cost reductions are not achieved this doesn't imply the farm is unprofitable and there may be alternative drivers for adopting OAD.
- More information is available at [dairynz.co.nz/full-season-OAD](http://dairynz.co.nz/full-season-OAD)



### Impacts of OAD on milk production: published research and commercial herds

When evaluating the economics of OAD milking for an individual farm, the principal consideration is the impact on profitability through changes in milk production and operating expenses. Feedback from farmers on OAD suggests that the observed decreases in milk production on commercial farms are less than that reported in research experiments. With the recent analysis of data from commercial farms<sup>2</sup> it's now possible to provide clearer guidance to farmers considering the use of strategic OAD milking.

There have been two published reviews of scientific literature on OAD milking<sup>3,4</sup>, which demonstrate that the majority of research into OAD milking has focused on tactical use. Due to the variety of situations where OAD might be used tactically, it is not surprising that there is considerable variation in the effect on milk production – ranging from a 7 to 40% reduction<sup>4</sup>. On the other hand, the most recent review<sup>4</sup> cited only four controlled research studies on the strategic use of OAD<sup>5-8</sup>, where the decrease in milk production ranged from 22 to 50%<sup>4</sup>. Again, there are a number of reasons for this variation, including breed, lactation number and management system, which should be put in context.

Two of these four studies were conducted overseas, one during the 1950s using only first (50% reduction in milk yield) and second (40% reduction) lactation cows<sup>5</sup>. These cows were Swedish Red and White cows, grazed only during summer months. The second was in France using Holstein-Friesian cows fed mixed rations for all but the summer months (30% reduction)<sup>6</sup>. Other studies have suggested that first lactation animals experience a greater production loss and that Holstein-Friesian cows are less tolerant of OAD<sup>8</sup> so it is not surprising that these results differ from some New Zealand observations.

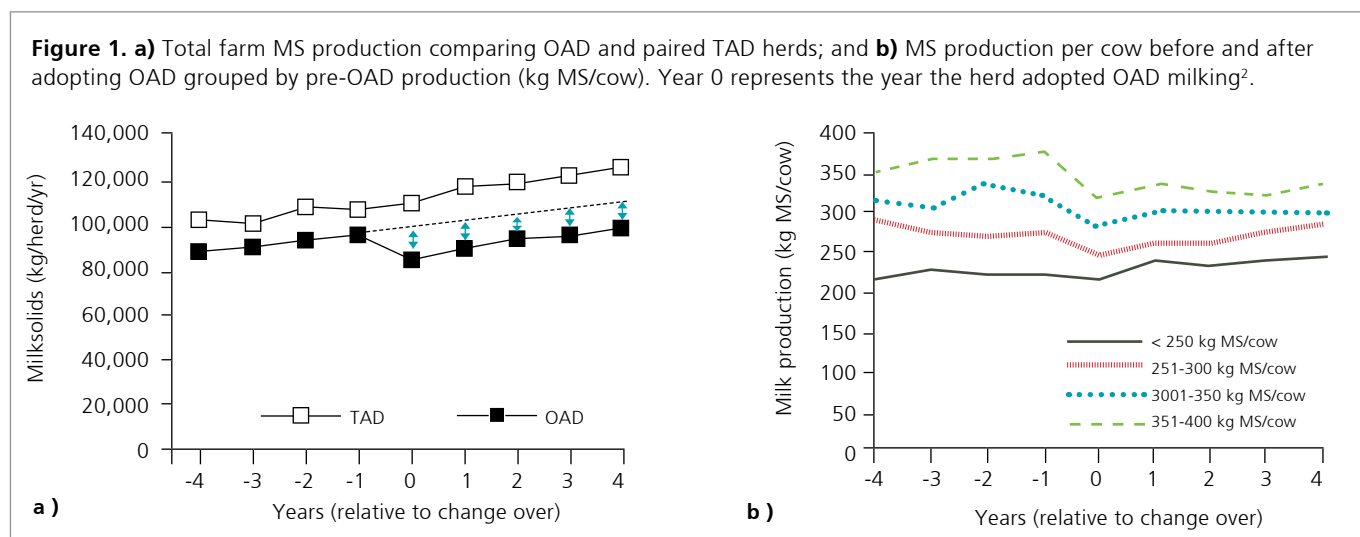
Understanding the methodology is important when comparing research results. For example, the 30% change reported in the French study was for milk yield, which equates to 25% for kg MS/cow<sup>6</sup>. A 20-29% kg MS per cow loss was reported from the most comprehensive New Zealand study, a four-year experiment in Taranaki but on a kg MS/ha basis, production losses were 6-16% as stocking rates were higher in the OAD treatment<sup>8</sup>. The

range reported in this study was due to breed, with Jersey cows being more tolerant of OAD milking than Holstein-Friesians.

Recently, two studies have reported comparisons of OAD and TAD milking in commercial herds<sup>2,9</sup>. Results from the first study indicated Jersey and Friesian-Jersey cross cows were less affected ( $\leq 19.0\%$ ) than Holstein-Friesians (19%-25%) on a kg MS/cow basis<sup>9</sup>. The second study reported an average of 11% decrease in kg MS/herd between the first year milking OAD and the previous season (Figure 1a) for herds that adopted OAD milking between 2007/08 and 2015/16<sup>2</sup>. In this study OAD herds were identified using herd test data and paired with TAD herds located within 25km, 20% herd size and 14 days planned start of calving. Farm-gate milk production data and area were also collated for these herds. The data was analysed using the effects of year, milking interval and the interaction of year and interval. The stocking rate of the OAD herds was 2.6 cows/ha before and after adopting OAD, compared with 2.7 cows/ha for the TAD herds.

Figure 1b demonstrates that commercial herds producing <250 kg MS/cow had a minimal (2%) decrease in milk production and, after a year, increased production. In comparison, herds producing 351-400 kg MS/cow experienced the largest decrease (16%) and did not regain their prior level of production in the period reported. In terms of kg MS/ha the decrease was 7% for the <250 kg MS/cow group and 16% for the 351-400 kg MS/cow group. Udder physiology research indicates that milk secretion is linear up to 16 hours<sup>3,10</sup>, with a decrease in the rate occurring between 16 and 24 hours. However, there were large variations in the secretion rate between animals<sup>10</sup>, with lower producing animals typically having linear milk secretion rates beyond 16 hours, which may explain the minor effect on production for the <250 kg MS/cow group.

The ability of the <250 kg MS/cow group to increase production after the first season of OAD may be due to the removal of a management limitation on the farm. Farmers have stated that their motivations for adopting OAD include wanting to improve the condition of a herd, manage health issues or reduce walking distances<sup>11</sup>. Less energy spent walking may increase the feed available for production. A Massey University study<sup>7</sup> indicated that cows milked OAD ate 7% less



during September to December, with no difference in intakes from January to April, calculated using a rising plate meter to measure pasture disappearance (a proxy for intake). Intake was also measured on a small number of cows within the experiment using a chromium marker, which suggested an 8% decrease in intake in November and January. These figures are less than the decrease in milk production (34%), likely due to energy being diverted to liveweight and body condition gain.

### OAD implications on farm economics

Results from the multi-year Taranaki experiment<sup>8</sup> and the comparison of commercial herds milking OAD<sup>2</sup> indicate a farm milk production loss of 6-16% might be expected, depending on factors such as breed and per cow production. Assuming no other revenue sources, this implies costs (farm working expenses + interest & rent) must be reduced if equivalent profitability is to be maintained. Interestingly, Figure 1a highlights that while the commercial OAD herds regained their prior (year -1) production by the fourth season (year 3) they remained behind their TAD peer group (i.e. the lines did not converge). Hence, the cost reductions should be permanent for OAD milking to be as profitable as TAD.

The cost reduction required to maintain equivalent profitability can be calculated using this formula:

$$\text{Cost reduction (\$/kg MS) required} = \text{\% change in farm milksolids} \times \text{milk price}^2$$

As an example, a 10% decrease in milk production at a milk price of \$5.50/kg MS means costs should be reduced by \$0.55/kg MS for equivalent profitability. The difficulty with which this can be achieved will depend on the initial cost structure. Those with already low costs or high fixed costs (e.g. interest or irrigation) will find it more challenging. It will also be more challenging at higher milk prices as the cost reduction required will be greater<sup>2</sup>. Note, using OAD to prevent an increase in costs (e.g. interest on a new dairy shed) could be considered a cost reduction. Preparing a budget, including estimating where costs can be reduced, is essential prior to adopting OAD. If the target cost reduction is not achieved this does not imply that OAD is unprofitable, and some farmers may place a greater importance on lifestyle, labour flexibility or herd management<sup>11</sup>.

Few studies have evaluated the economics of commercial OAD farms. One such study of 22 farms using strategic OAD milking, indicated that farm working expenses decreased by 25%, with a 6% decrease in farm milk production<sup>12</sup>. Savings were made in labour, animal health and breeding, dairy shed and electricity, and farm vehicle expenses<sup>12</sup>. An Australian case study (high supplement input by New Zealand standards) concluded that the profitability of switching to OAD depends on cash labour savings or real earnings from off-farm employment as many owner-operators do not pay themselves a wage<sup>13</sup>. They estimated OAD was more profitable if the decrease in farm milk production was less than 12%<sup>13</sup>. Interestingly, they also concluded that it was more important to concentrate on minimising production loss per cow (depending on

its cost) than increasing stocking rate, contrary to earlier advice<sup>7</sup>. This may explain the greater adoption of OAD in regions with lower production levels<sup>2</sup> where the production loss is minimised (Figure 1b). Nationally, around 19% of herds produce less than 300 kg MS/cow<sup>14</sup>. A robust economic evaluation of full-season OAD for New Zealand conditions is warranted.

### Other farm system implications

Research indicates improved reproductive performance under OAD milking<sup>8</sup>, resulting in a more compact calving pattern<sup>2</sup>. While this could increase days-in-milk, offsetting the decrease in milk production, this is not generally observed, likely due to low milk volumes at dry-off. Feed costs may be higher in spring to support the earlier mean calving date (unless planned start of calving is adjusted)<sup>2, 8</sup> but lower in winter due to better body condition<sup>8</sup>.

### Conclusions

Results from commercial herds milking OAD indicate that a milk production loss of 6-16% can be expected. Therefore, the key consideration for the economics of adopting OAD is the extent to which costs, principally labour, can be reduced in relation to the expected decrease in farm milk production. Farms with a current low per cow production have a greater opportunity to successfully adopt strategic OAD milking, when compared with higher producing herds, due to expected production losses being less severe.

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## *Crop type and management affects the risk of nitrate leaching loss<sup>1</sup>*

Since the release of the New Zealand Government's National Policy Statement for Freshwater Management in 2011, our grazing systems have experienced increased scrutiny with regards their environmental impact. Of particular interest has been the role of the urine patch on nitrate (NO<sub>3</sub>) leaching losses. Any nitrogen (N) surplus to animal requirement is excreted, with a high proportion ending up in urine. The N loading of a single urine patch can range from 300 to 1000 kg N/ha depending on the N intake of the animal; significantly more than the plants in and near the urine patch can capture immediately for growth. N not utilised by plants is then at risk of leaching below the plant root zone if drainage occurs. Slower plant growth rates, bare soils and increased risk of drainage during winter and early spring make urine patches deposited in late autumn, winter and early spring most vulnerable to NO<sub>3</sub> leaching.

Offering feeds with a lower N content is one strategy to better match N intake with animal demands. However, in our pasture-based systems there is limited opportunity to manipulate the N content of the diet without introducing alternative feeds into the system. Feeds with a high energy (soluble sugars and starch; SSS) but lower N content offer the most potential. We were interested in understanding the variation in N and SSS content of crops and supplements available in NZ grazing systems. Data from 2770 crop samples,

representing 71 crops or crop mixtures, were collated into a database. Although legumes had the highest average N content, for most crops there was a 2-fold range in N concentration within crop type. Understanding the drivers of this variation in N content provides opportunity to manipulate crop management during growth and/or harvesting to provide feeds that better match the N requirements of different classes of livestock. Factors such as cultivar, geographic location, sowing density, stage of maturity, fertiliser history and climate can all affect the N content of the plant at harvest.

Feeds most likely to result in less urinary N excretion and therefore reduced NO<sub>3</sub> leaching risk included fodder beet, swedes, turnips, barley and wheat grain, maize silage and whole crop cereal silages. The high SSS of many of these feeds will support high animal production but may increase the risk of nutritional disorders if fed as a high proportion of the diet.

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