Meeting a Sustainable Future

Canterbury | Inspiring High Performance, Low footprint farms

Farming under a N Fertiliser Cap

Learnings from the Hinds and Selwyn Partner Farms and Science Evidence

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DairyNZ

Meeting a Sustainable Future – Selwyn and Hinds

Inspiring High Performance, Low footprint farms

Through this DairyNZ five-year project, Canterbury dairy farmers will lead the way in showcasing how nitrogen (N) losses can continue to be reduced in order to protect local waterways.

The project focuses on how farms in Hinds and Selwyn can meet N loss limits and maintain profitable businesses under the Canterbury Land & Water Regional Plan (LWRP). Reducing N is a key focus for the project as both catchments have N reduction targets; however, this project also focusses on other aspects of environmental footprint including, Phosphorus and Sediment losses and Green House Gas emissions.

This project builds on sustainable farming initiatives many farmers have already begun and on previous N loss research. It aims to give farmers confidence the limits are achievable. Many farmers have been making changes to reduce N loss for some time and this will continue to build on that.

A key aspect of this project is working alongside partner farms to identify the most appropriate solutions for them, considering their chosen production systems, goals, and aspirations. The information generated from these partner farms is being shared with other farmers and provide a good range of examples and options. In this approach we are also partnering with the rural professionals working with the farmers.

What does success look like?

- Farmers will have confidence in the options available to reduce environmental footprint and an understanding of the implications of these options on the overall performance of their production systems.
- The options will be demonstrated to other farmers as they are implemented.
- Farmers will have clarity on the most profitable options to reduce their environmental footprint in different conditions and farm systems.

How can you get involved?

If you are a farmer, you could become one of the supported farmers or engaged with the range of extension activities.

If you are a rural professional, you can work with the project team to provide research questions and find the most appropriate solutions for your client farmers.

For more information about the project please contact Virginia Serra (021932515/virginia.serra@dairynz.co.nz) Project Lead

Farming Under a Nitrogen Fertiliser Cap

Learnings from the Hinds and Selwyn Partner Farms Network

Nitrogen Fertiliser Cap

On the 28 of May 2020 under Essential Freshwater the government announced a package of measures and restrictions aiming at improving water quality across the country. Some changes were already part of the original document released in October 2019, but other recommendations were new such as the limit on synthetic Nitrogen (N) fertiliser use at 190 kg N per ha on pastoral farms. The N cap is proposed to begin in July 2021 and pastoral farmers must report N fertiliser use to their regional council.

N Fertiliser Use and the N cycle

Nitrogen fertiliser is only one of the inputs entering the N cycle. N inputs into the system also include N in other feeds, clover fixation and a small amount from irrigation water. Direct losses from N fertiliser are low; as the main N losses from a dairy farm come from the urine patches, where the N eaten by the cow is concentrated in a small area. The N concentration in the urine patch is much greater than what plants can take up and therefore at risk of being lost from the root zone and potentially into waterways.

Over the last 18 months we have been working alongside a group of farmers in the Hinds and Selwyn catchment to identify the best options to reduce N leaching on their farms. Many of the options considered have been identified and demonstrated in previous research projects such as Pastoral 21 and FRNL.

In Canterbury, under the Land and Water Regional Plan farmers are required to reduce N losses from their farms (outputs). This approach considers all drivers for N loss and risk factors (whole N cycle) before deciding what levers to pull. The N cap regulation brings the focus on one input, “N fertiliser”, reducing the focus on whole farm systems solution and innovation. This approach could bring unintended consequences such as an increase in supplementary feed to compensate for potential pasture growth reductions. Similarly, an increase in N fixed by clover (compensating less N from fertiliser) will increase the amount of N entering the system.

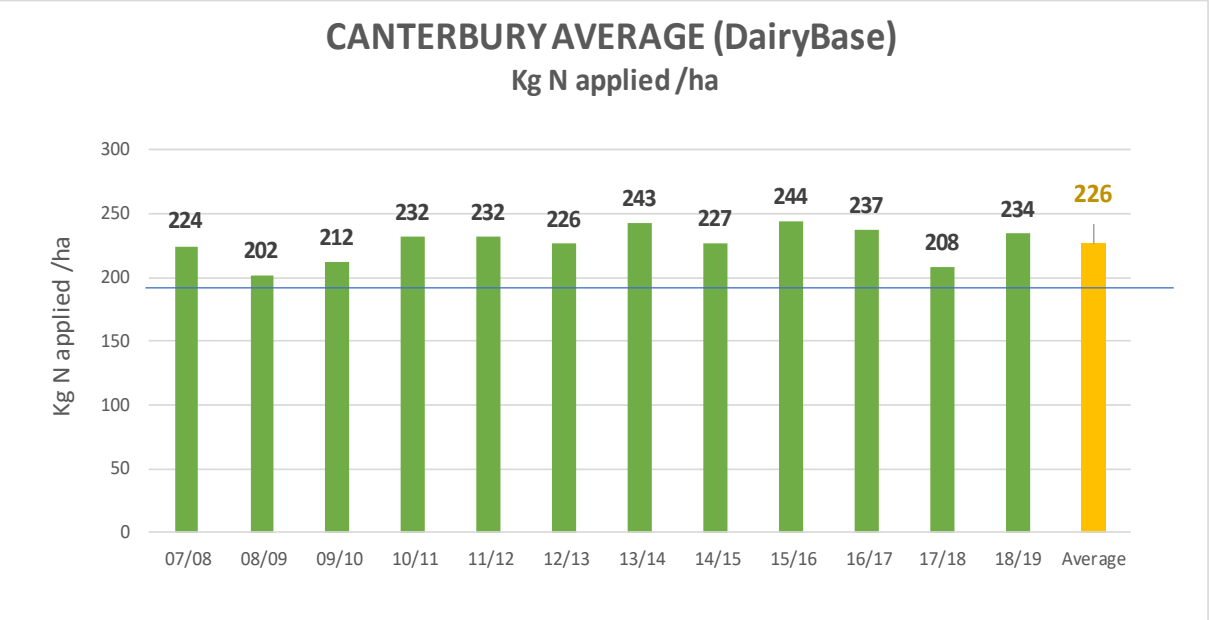
Despite the points presented before, N fertiliser use is highly correlated to N Surplus and N leaching. Therefore, reducing N fertiliser use is likely to contribute to the final desirable outcome of reducing N in water. Reducing N fertiliser has been one of the strategies followed by some of the partner farms involved in the Hinds and Selwyn project and this document summarises some key learnings.

Nitrogen Use in Canterbury

Assuming no other limiting factors, irrigated farms in Canterbury can expect high response rates to N fertiliser (10-15 kg DM/kg N applied) for a considerable part of the season, making N boosted grass a very price competitive feed, explaining the higher use of N fertiliser in Canterbury compared to other regions. The average N use on Canterbury dairy farms varies slightly depending on the data set considered.

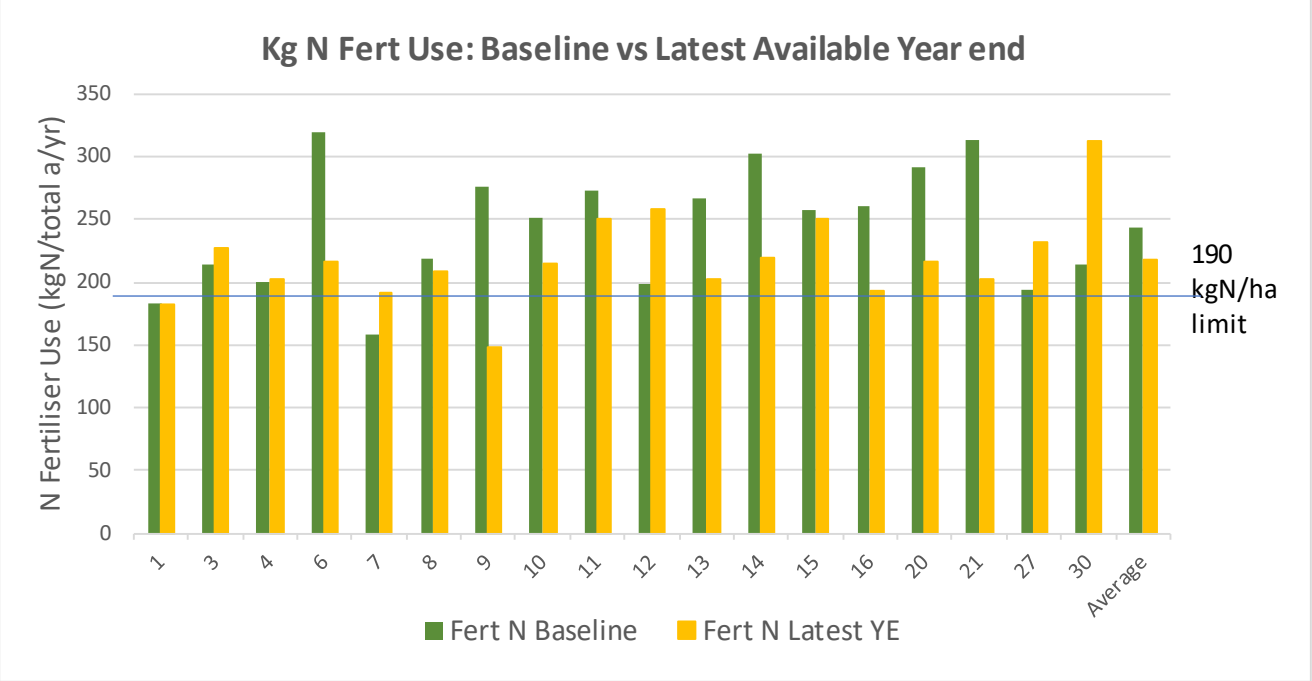
- DairyBase data shows that for the 2018/19 season the average N use was **234 kg N/ha** effective.
- For the same season, the average N use for the farms involved in the Canterbury benchmark project (a subset of farms on DairyBase in Canterbury) was **227 kg N/ha** effective.
- The average N use for the latest year ends available for the partner farms involved in the Hinds and Selwyn project was **218 kg N/ha** compared to 244 kg N/ha during the baseline period (11% reduction).
- The average N use for last year for Irrigo dairy farmer shareholders was **227 kg N/ha** compared to the average over the past 4 seasons at 247 kg N/ha **(**data supplied by Eva Harris - Irrigo)

Graph 1: Kg Nitrogen applied in Canterbury over the last 12 years (source DairyBase)



Graph 2 compares N use in the baseline period (2009-2013) with the latest years available for nineteen of the partner farms involved in the Hinds and Selwyn project. The average N use for the latest year ends available was 218 kg N/ha compared to 244 kg N/ha during the baseline period (11% reduction). Four of these farms had increased N use compared to the baseline period. The year ends (yellow bars) represent the latest year end available for each farm which in most cases are the 2017/18 or 2018/19 seasons.

Graph 2: Hinds and Selwyn Partner farms- Kg N applied /ha: Baseline Period & Year end.

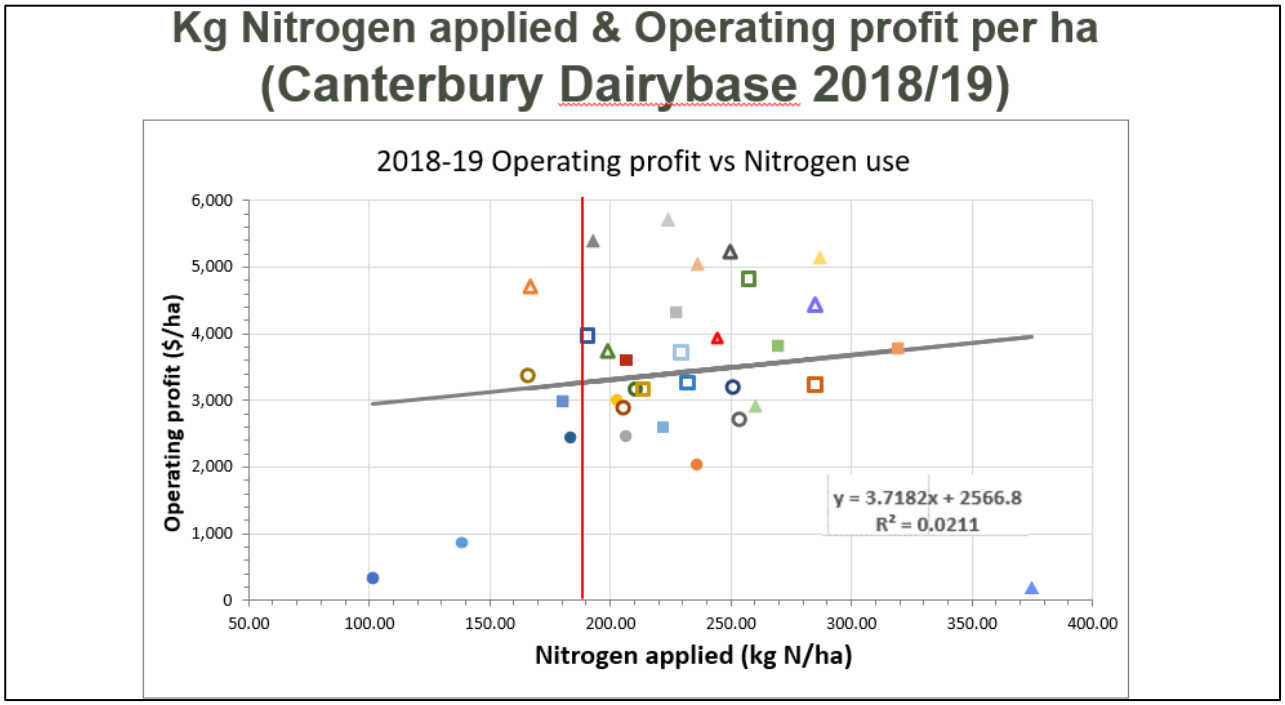


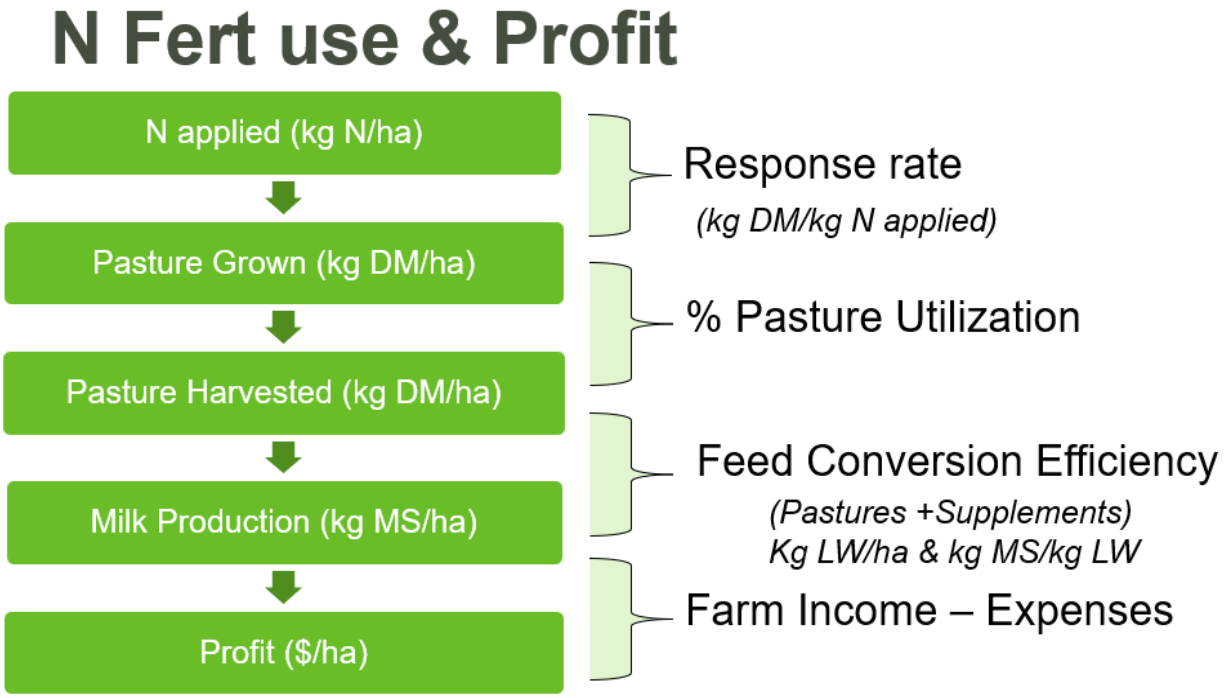
Please note that the data from the partner farms presented in this document comes from Overseer which calculates N fertiliser used divided by the total area of the farm and not effective area as it is calculated in DairyBase.

Nitrogen Use, Pasture Harvested and Profit

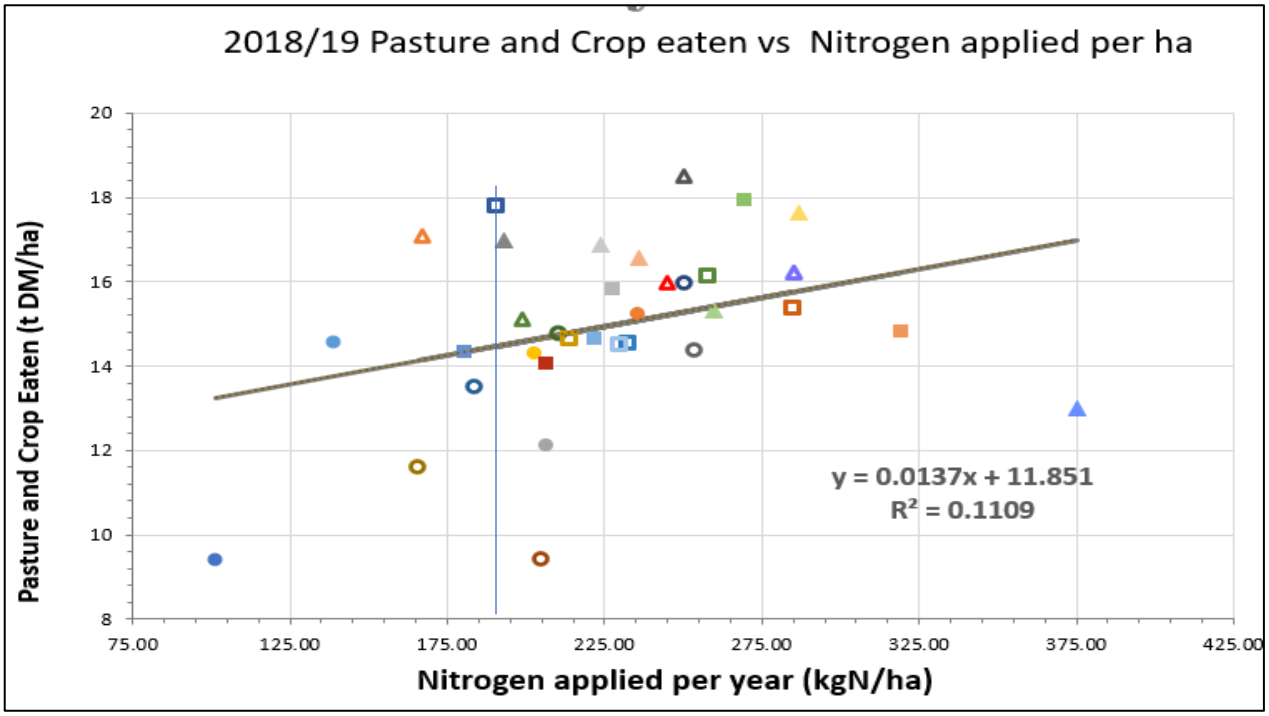
The correlation between nitrogen applied and profit is quite low as presented in graph 3. Lower N fertiliser use is likely to reduce pasture growth, however how pasture is managed and utilised can minimise the impact on milk production and profit.

Graph 3: N Fertiliser use and Profit ($/ha)





Graph 4: Kg Nitrogen applied & Pasture and Crop Eaten (Canterbury DairyBase 2018/19)



The correlations between nitrogen applied and Profit (Graph 3) and nitrogen applied and pasture harvested (Graph 4) are quite low.

For the same amount of N fertiliser used there are several factors that will influence how much pasture is grown and harvested. Some of these factors are:

- Nitrogen use efficiency affected by timing of N fertiliser, rate of applications and environmental conditions influencing pasture growth (soil temperature, soil moisture, other nutrients etc.)
- Time available for N response (timing between N application and grazing)
- Clover content on the pasture and its management
- Effluent block management
- Factors affecting the release of N in the soil (e.g. cultivation)
- Pasture management and monitoring that can affect pasture utilization

Details of these factors are described in the Inside Dairy articles included at the end of the handout.

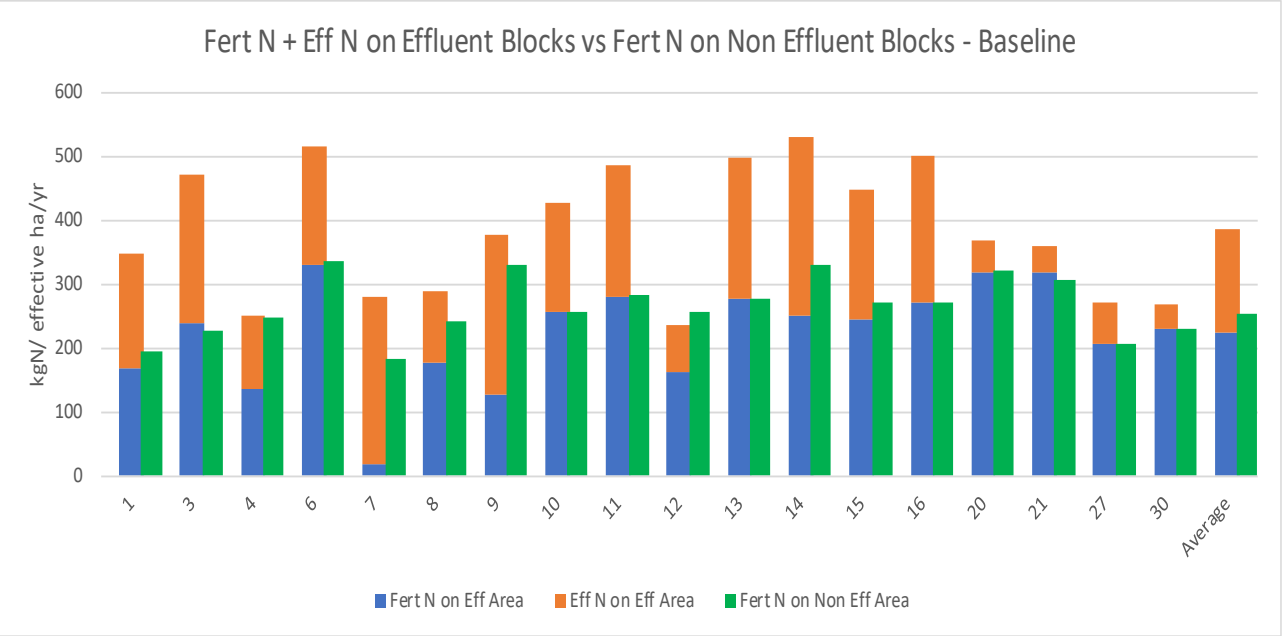
Similarly, how pasture harvested will translate into profit will depend on several factors including:

- How efficient pasture and supplement used are converted to milk production.
- Proportion of feed going into maintenance and milk production
- Cost of feed and overall operating expenses
- Milk price

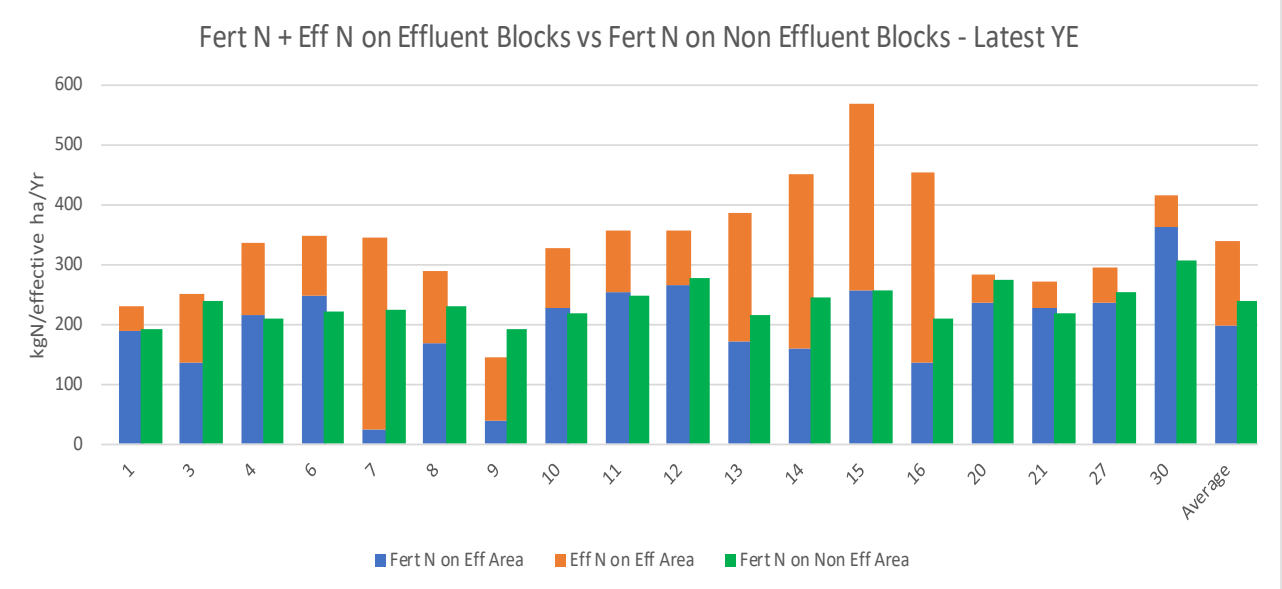
Nitrogen Use: Effluent and non-Effluent Blocks (Partner farms)

Graphs 5 and 6 shows for nineteen of the partner farms in Hinds and Selwyn the amount of N fertiliser applied on the non-effluent blocks compared to how much total N is applied on the effluent block (from effluent and fertiliser).

Graph 5: Kg Nitrogen applied effluent/non effluent blocks: Baseline Period



Graph 6: Kg Nitrogen applied effluent/non effluent blocks: Year ends



Comparing the latest year end available with the baseline period, on average there has been an 8% increase in the effluent area and a 11% reduction in N fertiliser applied in the effluent block. As we can see in these graphs for a few of these farms there has been a reduction in the amount of Nitrogen from fertiliser applied on the effluent blocks but there are still a few farms using significant amounts of Nitrogen fertiliser on effluent blocks.

Lessons Learnt from the Hinds and Selwyn Partner Farms

High N users (> 300 kg N /ha/yr) possible mistakes:

- Following the cows with Nitrogen applications. It is a simple strategy but can lead to using too much nitrogen and more than what is required. This can be worse when fast grazing rounds are used.
- Fast rounds (18 -19 days). Under fast grazing rounds pasture is grazed below the 2.5 leaf stage rather than between 2.5 and 3 leaf stage missing out on a period of highest accumulation of growth.
- Using high rates each time that cannot be fully used by plants increasing the risk of being lost.
- Inadequate pasture monitoring and recording to inform decision making
- The extra N boosted grass grown is poorly utilised, e.g. excessive pre-graze mowing or topping after grazing
- Inadequate and/or inaccurate monitoring of N fertiliser applied leading to higher N used than expected at the end of the season

Successful transition to lower N fertiliser use

- Significant reductions in N fertiliser use (+ 60 kg) will require time to adapt to the new system to minimize its impact.
- Several farmers have reduced N fertiliser use successfully from +300 kg N/ha to 200-230 kg N /ha over 2-3 years.
- A successful transition requires time and it is best to do it gradually. Important that clover has time to re-establish itself and it is actively fixing N. Clover will need time and care to come back to pastures if not present currently.
- Farmers with high N use must reduce N fertiliser this season to be able to be under the N cap next year. An option is to target half of the reduction required this season and the other half next season.
- It is important to lift any other limitations, e.g. soil fertility, weeds, irrigation etc.

How to increase N use efficiency to support low N fertiliser use – Top Tips

- Having a plan, following it and monitoring progress. Plan to be adjusted during the season, in response to weather etc.
- Applying less N fertiliser on effluent areas. Some issues/concerns: N content of effluent can be variable, and practicalities of the system may limit how much N fertiliser can be adjusted over the effluent area.
- Considering good clover establishment at pasture renewal time, ensuring good soil fertility and grazing management to avoid shading of clover. Clover (if present) will fix N and compensate the lower N from fertiliser.
- Moving to lower rates when possible: e.g. moving from 1 kg N per day of round length to 0.8 kg N per day of round length. Using mixes to get lower N rate e.g. potash and N, DAP, SOA (but may increase cost).
- Following the cows with N fertiliser can be an easy strategy but can lead to high N use, especially if getting into fast rounds. Many farmers have moved to applying N once a month or twice a month. However, some N efficiency may be compromised as some paddocks will be in the middle of their regrowth.
- Slower rounds would reduce number of applications and give grass more opportunity to grow.
- Timing of applications. Most farmers do the last application in mid-April and usually start the first application in August as soon as temperature is above 7°C, but others have delayed the first application to September. No applications in January or February (at peak clover growth) has been a popular strategy as well but with mixed results, e.g. ending up with a feed deficit in March. Other

farmers will just reduce application rate during that time. Every season is different and it may not be possible to have a rigid policy of avoiding application for a particular month.

- Addressing soil fertility to ensure there are no other limitations for pasture growth especially considering clover requirements (pH, P and K).
- Considering avoiding areas of higher fertility within paddocks (e.g. first 20-30 meters into a paddock, area around the trough) and areas of the farm likely to have low response to N, e.g. dry areas, poorer species.
- Checking precision tracking and monitoring as it can be a surprise at the end of the year.
- Coated urea (N-Protect, SustaiN) and Pro-gibb are commonly used to reduce N rate without affecting pasture production. Fertigation can be used to reduce rates without compromising distribution of the fertiliser.

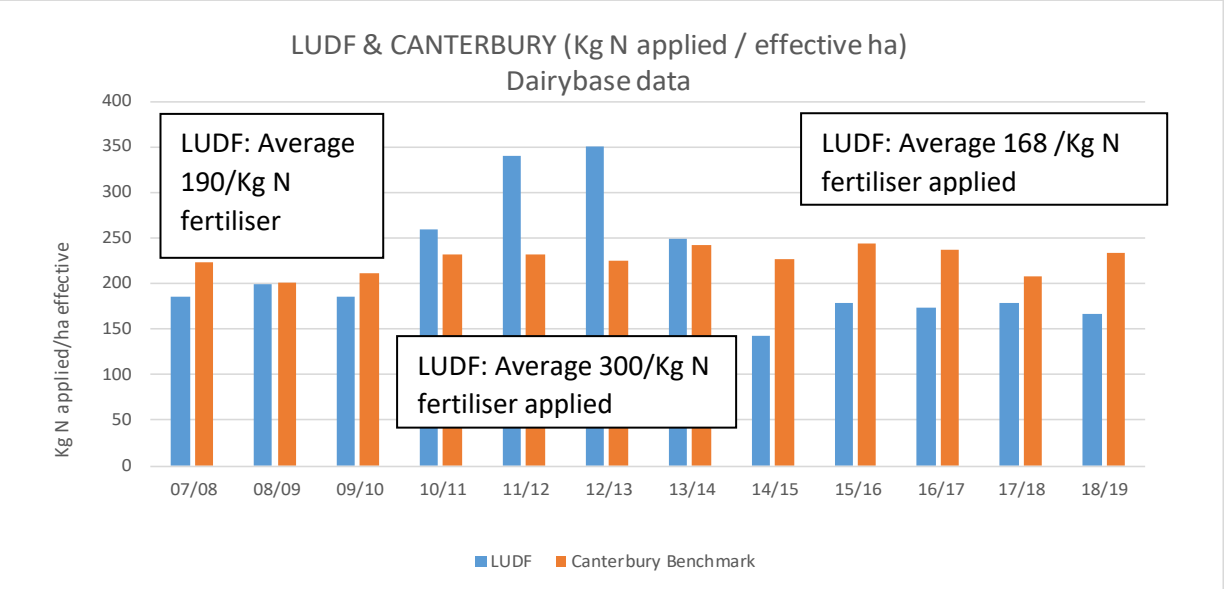
Further Research questions:

- Timing of fertiliser application during the regrowth. What is the impact of putting N a few days before grazing instead of just after grazing? How late can we go? Relevant for farmers who are using a fixed date to apply fertiliser on half the farm or the whole farm at once.
- If missing an application, when is better to do so and why. There were contradictory experiences about removing application in February for example. Some people have been doing it successfully and others have struggled with loss in production. Other farmers suggested not to use N in August and start later in September.
- N in effluent, how storage affects N content of effluent. Data shows large variation, making it difficult to translate to something practical.

N Fertiliser Policy Lincoln University Dairy Farm (LUDF) – An example

The Lincoln University Dairy Farm had a significant change in the nitrogen use strategy over the last few years. The spread of the clover root weevil in Selwyn in the early 2010s decimated clover on many local farms including LUDF, prompting an increase in N fertiliser use from around 189 kg N/ha (average from 2003/4 – 2009/10 seasons to 250 – 350 kg N/ha (from 2010/11 to 2013/14 seasons). Eco-N was used during this period to reduce the risk of N leaching until it was removed from the market in 2013. From the 2014/15 season (when the farm implemented the principles from the Pastoral 21 research project) N from fertiliser was reduced gradually to the current N use. Graph 7 shows N fertiliser use for LUDF and the average for Canterbury.

Graph 7: Kg Nitrogen applied Lincoln University Dairy Farm



Graph 8 presents the N use efficiency (kg MS/kg N fertiliser applied) for LUDF and the average for Canterbury. For LUDF there was a significant increase in N use efficiency (10.4 versus 6.2 kg MS/kg N fertiliser), a remarkable improvement in the overall system efficiency and a key step toward reducing the N footprint of the farm. For Canterbury farms the average milk solids production per kg N applied, for the last 12 years, was 7 kg MS/kg N ranging from 6.5 to 7.9 (source Canterbury- DairyBase).

The reduction in N fertiliser was implemented using two main methods:

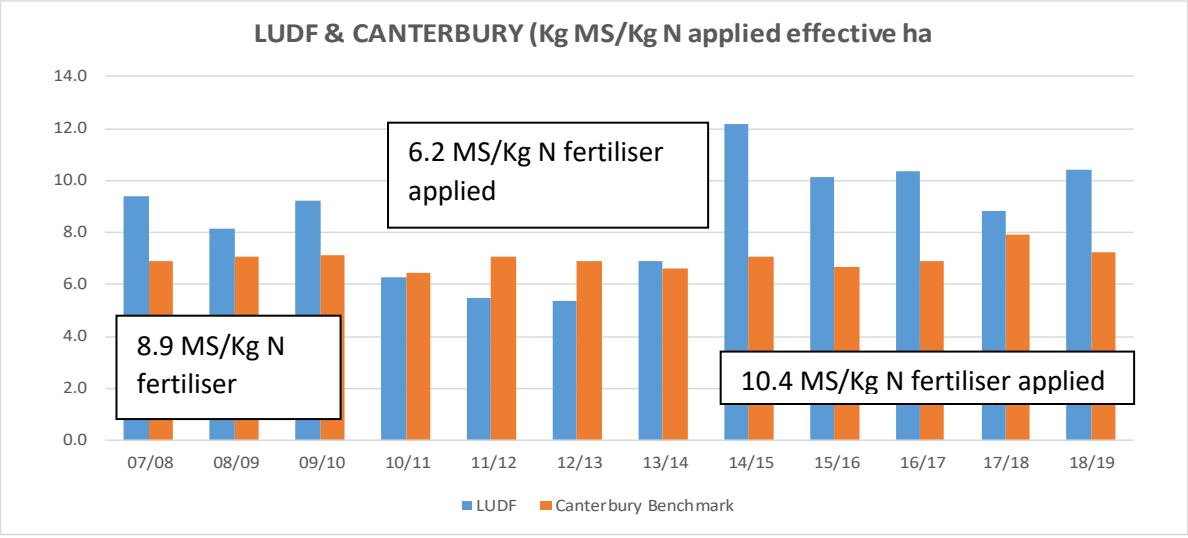
- Changing the frequency and amount of N applied at each event – contributing to 85% of the overall reduction in N applied
- Markedly reducing N fertiliser applied to the effluent areas – contributing to 15% of the reduction in total N applied

A key feature of the change in fertiliser management was: (LUDF data analysed by David Chapman - DairyNZ.)

- 2.4 fewer applications per year, and an average of 8 kg N/ha less N applied at each fertiliser spreading event
- The fewer applications per year was, in turn, facilitated by 1.7 fewer grazings per year reflecting a mean 4-day increase in rotation length
- The increase in rotation length resulted in an increase in leaf stage at grazing of ~ 0.3 leaves/grazing, which was estimated to have recouped about 1.1 t DM/ha of the expected reduction in pasture growth resulting from removing N fertiliser
- This explains most, if not all, the 'buffering' of pasture yield reduction resulting from removing N fertiliser

Having a high percentage of tetraploids in the pastures (95% of paddocks now have at least some component of tetraploids) has helped with the higher pre-grazing covers generated by the longer grazing rounds. Pre-grazing mowing has also been used to achieve the targeted residuals. It is important to mention that clover has returned to the pastures as it was before the clover root weevil outbreak.
There were also differences in the timing of N fertiliser applications with no N applied after the end of March. This can contribute to lower leaching not necessarily via direct leaching of N from fertiliser but by having fewer grazing events into the late summer-autumn period where the N leaching risk of urinary N increases.

Graph 8: Kg Milksolids/ Kg Nitrogen applied LUDF (source Dairybase)



Tactical use of nitrogen fertiliser

Find out how nitrogen fertiliser use can be carefully targeted and managed to assist pasture growth, without compromising the environment or your profits.

Ina Pinxterhuis, senior scientist, DairyNZ

KEY MESSAGES

- New Zealand grass/clover pastures are inherently nitrogen (N) deficient and will respond to N fertiliser when growth conditions are right.
- Many farmers have moved from a tactical use of N fertiliser to fill feed deficits, to production systems that rely on N fertiliser all year round.
- Higher N application and pasture yields increase animal N intake per hectare and urinary N excretion, which increases the risk of N loss to the environment.
- Overseer is responsive to reductions in N fertiliser rates, so when N leaching limits apply, N fertiliser use should be evaluated.
- Farm N surplus and kg milksolids produced per kg N fertiliser indicate if N fertiliser rates are compromising profit and environment.
- Restricted annual N fertiliser rates increase the need for tactical use of N fertiliser.

Nitrogen fertiliser use in New Zealand

With the limelight on high-input farming systems and nitrogen (N) contributing to water quality degradation and greenhouse gas (GHG) emissions, it's timely to re-visit how best to use a lesser amount of N fertiliser on grazed pastures.

In the last 25 years, the annual application of N via fertiliser has increased more than six-fold in New Zealand, from 59,000 tonnes in 1990 to 429,000 tonnes in 2015. The dairy sector is the largest user: 63 percent of all N fertiliser used in New Zealand[1].

This increase has been partly due to an increase in land area used for dairy farming[2], but annual rates of N used on dairy farms have also increased in general. For example, an average use of 40kg N/ha in the late 1990s has increased to an average use of 45kg N/ha for System 1 farms, and up to 156kg N/ha for System 5 farms (overall average 126kg N/ha) in 2015/16[3].

Seasonal considerations

N fertiliser trials in the 1970s and 1980s showed that well-managed ryegrass/white clover pastures in New Zealand were N deficient, responding well to N fertiliser.

In late autumn to early spring, low temperatures usually restrict clover growth, N fixation and mineralisation, resulting in less N available for the grass[4]. So N deficiency is more pronounced in spring, when soil temperature and moisture don't limit grass growth, and rapid production responses to fertiliser N can be expected[5].

Consequently, the tactical use of N fertiliser in autumn and early spring was promoted to maintain the N fixation and feed quality benefits of clover in late spring through to early autumn.

Care needs to be taken to avoid long-lasting shading of clover stolons (runners) in spring by prolonged canopy closure (e.g. with heavy silage cuts). Shading of clover stolons reduces branching. This reduces clover production and, hence, N fixation later in the year, risking lower summer pasture yields.

Response to autumn applications could be too slow to fill autumn feed gaps but could help to achieve desired pasture covers going into winter.

What's the approach since then?

From the 1990s on, the increased rates of N fertiliser illustrate a move away from relying on clover N fixation and shifting to frequent N applications (e.g. routinely after every grazing or silage cut). It can be easier to manage N-fertilised pasture than clover-based pasture because of greater predictability of pasture production and less year-to-year variation[6]. Also, when N fertiliser is applied during good pasture growth conditions and additional pasture is utilised to produce milk, N fertiliser use is nearly always economical.

How high is too high?

High rates of N fertiliser achieve pasture production greater than can be achieved with N fixation in grass/clover pastures, when growth conditions are favourable (i.e. no lack of other soil nutrients and water, optimal temperatures, no weeds, no pests and no diseases).

However, if higher pasture production is utilised by grazing animals, total N intake/ha is greater, and more N is excreted in urine. This reduces the efficiency of N use, increases the farm's N surplus and increases the risk of N loss to the environment (for an example, see *Figure 1*). Results from DairyBase data presented in an earlier DairyNZ *Technical Series* article illustrate this[3].

Response indicators

There are several indicators available to assess if N fertiliser can be expected to provide sufficient pasture and milk production responses, or if the amount of N in the system poses a risk to the environment.

1. Soil organic matter or soil total N

Soils with a high organic matter or total N content have relatively high soil mineral N and mineralisable N available for plant growth. This reduces the need for N fertiliser[8]. Soil tests and associated recommendations are available commercially.

2. Farm N surplus or surplus of purchased N

This is the difference between N inputs (N in fertiliser and supplements = purchased N) and N outputs in products (milk, meat, crops) and is related to the risk of loss to the environment.

Efficiency gains are possible when a farm's surplus of purchased N is relatively high, for example compared with the median surplus of purchased N of 130kg N/ha for a System 4 dairy farm, and 70kg N/ha for a System 2 farm[3].

Note: Overseer's N surplus includes N inputs from biological fixation and irrigation water and is therefore higher than the surplus of purchased N.

3. Kg milksolids produced per kg N fertiliser

When production is low for the amount of N fertiliser used (<6kg MS/kg N fertiliser), N fertiliser use efficiency is low and a reduction in N fertiliser rate is likely to be profitable[10].

Figure 2 shows this is more likely to occur at annual N fertiliser rates of >200kg N/ha.

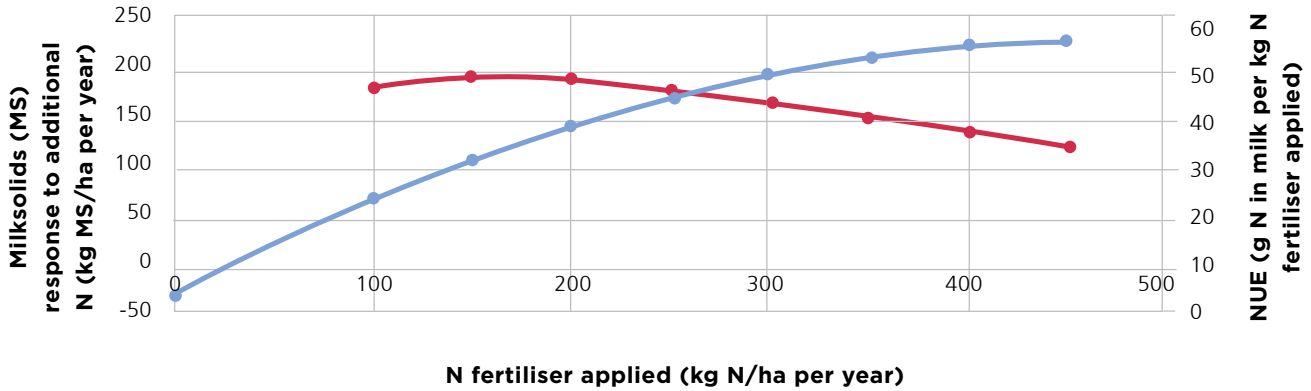
Increasing N use efficiency

Earlier publications have summarised good management practice for N fertiliser use, e.g. other DairyNZ *Technical Series* articles[11, 12] and DairyNZ's *Farm Facts* on plant nutrition[13]. A comprehensive overview is the *Code of Practice* published by the Fertiliser Association of New Zealand[14].

Here are some less well-known aspects of N fertiliser use[13, 14, 15, 16]:

- Pasture height needs to be above 3.5cm (~1500kg DM/ha) to respond to N fertiliser.
- Within four days after application, pasture does not respond to N fertiliser. This means it could be grazed without a response penalty in the following re-growth period.
- Thereafter, N uptake is rapid if growth conditions are good, but from four to 14 days after application, this is not yet converted to DM yield. Pasture N content is higher in these first weeks and, when grazed in this period, is associated with higher N excretion in urine and, therefore, higher risk of N loss to the environment.
- It takes 20 (spring) and up to 40 (autumn) days after application to get a significant yield response to N fertiliser.

Figure 1. Milk production response to additional N fertiliser*

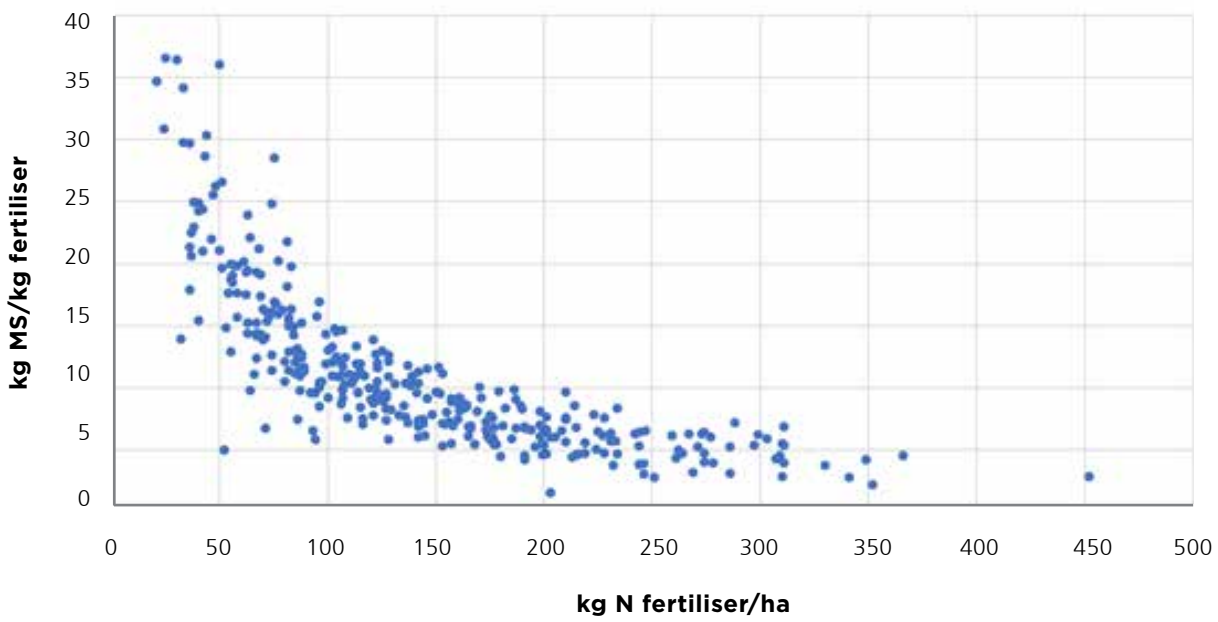


This graph indicates that milk production hardly responded to N fertiliser above 450kg N/ha.

At N fertiliser application rates of 100-200kg N/ha, the N use efficiency was greatest.

**(kg/ha, blue line, left hand axis) reported from seven farmlet studies conducted from 1971 to c. 1995[7], and the associated N use efficiency (NUE, grams N in milk per kg N fertiliser added, red line, right hand axis).*

Figure 2. Milksolids production per kg N fertiliser used plotted against annual N fertiliser rates



Data from 2015/16 DairyBase[3]

Well-managed ryegrass/white clover pastures are N deficient and respond to N fertiliser.

- At low soil temperatures (<6°C) pasture growth is limited and a response will not occur until soil temperatures increase again.
- High soil temperatures (>16°C) inhibit grass growth, and response to N fertiliser will be limited.
- Grazing should take place at the 2.5- to three-leaf stage of perennial ryegrass to ensure pasture quality is maintained and high growth rates are utilised. However, prolonged shading of the plant base should be avoided because it will reduce clover branching and grass tillering.

How to reduce N fertiliser use

When an assessment as indicated above indicates that a reduction in N fertiliser use might be environmentally or economically beneficial, a stepwise approach can be taken to adjust to a different N fertiliser management strategy.

The following recommendations are based on research cited above and on experiences from farmers participating in the Forages for Reduced Nitrate Leaching Programme*.

- Use applications of maximum 25 to 40kg N/ha. N applications of 40kg N/ha are useful only when conditions for pasture growth are optimal and pasture surplus to requirements for grazing is harvested for silage, to avoid high pre-grazing covers and residuals.
- Ensure round length is not faster than the number of days needed for significant yield response (e.g. 20 days in spring, see above) and that pasture is consistently grazed at the 2.5- to three-leaf stage. This may reduce the total number of grazings per year and 'automatically' reduce the number of N applications, if routinely following the cows with fertiliser.
- A longer round length reduces the N content in pasture and, therefore, urinary N excretion.
- Skip a few paddocks from your routine applications when pasture growth rates are high and silage making is not wanted/needed. A weekly farm walk and constructing a feed wedge will help with these decisions.
- Skip N applications on paddocks in summer when clover content is high.
- Reduce or don't apply N fertiliser in late autumn, when average cover is sufficient and risk of drainage is increasing.
- Ensure N fertiliser is applied to the paddocks targeted. If using contractors, check the application tracking data.

** The Forages for Reduced Nitrate Leaching programme had principal funding from the New Zealand Ministry of Business, Innovation and Employment and co-funding from research partners DairyNZ Inc, AgResearch, Plant & Food Research, Lincoln University, Foundation for Arable Research and Manaaki Whenua – Landcare Research. See* **dairynz.co.nz/frnl**

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