December 2019

Issue 44

TECHNICAL SERIES

SCIENCE IN ACTION

REMOVING IMPORTED FEED

What are the effects?

Targeting N fertiliser use

The power of modelling field trial data

Fat price's effect on breed profitability

DairyNZ

CONTENTS

Measurement	Meaning
cm	centimetres
DM	dry matter
g	grams
GHG	greenhouse gases
ha	hectares
kg	kilograms
km	kilometre
m	metres
ME	metabolisable energy
ml	millilitres
mm	millimetres
MS	milksolids
L	litres
PKE	palm kernel expeller/extract
t	tonnes
<	less than
>	greater than
~	approximately, about

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ISSN 2230-2396 DNZ04-044

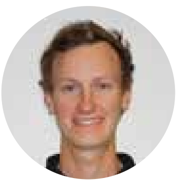
'PKE treatment' herd standing on the feed pad at the Northland Agricultural Research Farm. Photo: Northland Dairy Development Trust.

Effects of removing imported feed

What are the effects on production, environmental outcomes and profitability when removing imported supplementary feed from a pasture-based system?

KEY POINTS

- To maximise the milk production response, supplementary feed should be offered only when there is a genuine feed deficit (less than 1600kg DM/ha residual).
- Where supplementary feed is used to support a greater stocking rate, large milk production responses do not guarantee greater profit.
- Use of supplementary feed to increase total feed eaten/ha increases total methane emissions.



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John Roche, chief science advisor, Ministry for Primary Industries

When demand from the herd exceeds pasture supply, supplementary feed may be offered to increase dry matter (DM) intake and milk production[1]. This often comes with an expectation that this increased production will lead to greater profitability.

However, analyses of farm systems experiments[2] and farm databases[3, 4, 5, 6] challenge this. These studies concluded that, on average, increasing the amount of supplementary feed offered in pasture-based systems isn't associated with an increase in profitability, despite greater milk production and greater gross farm revenue.

Also, the intensification of grazing systems through increases in supplementary feed and stocking rate have often been associated with poorer environmental outcomes, such as reduced water quality and increased greenhouse gas (GHG) emissions[7].

This article describes the results of a recent farm system experiment that determined the biophysical, environmental, and economic effects of removing imported supplementary feed from a pasture-based dairy system.

System comparison

A three-year farmlet experiment, co-funded by DairyNZ and the Ministry for Primary Industries through the Sustainable Farming Fund, was analysed to investigate if New Zealand pasture-based farms could reduce their reliance on imported feeds and maintain profitability.

Northland Agricultural Research Farm.
Photo: Northland Dairy Development Trust.

The experiment was undertaken at the Northland Agricultural Research Farm (NARF), near Dargaville, during the 2015/16, 2016/17 and 2017/18 dairy seasons. Pastures at the site consisted predominantly of ryegrass and kikuyu.

As part of this analysis, two 28ha pasture-based systems, differing in stocking rate and the amount of imported feed, were compared. Treatments were:

- Palm kernel extract (PKE) — cows were stocked at 2.7 cows/ha, with PKE offered when post-grazing residuals were less than 4cm (approximately 1600kg DM/ha). This equated to an average allowance of 515kg DM/cow/year as PKE.
- Pasture — cows were stocked at 2.5 cows/ha, with the herd's diet consisting entirely of pasture grown on farm (grazed or conserved as silage).

System-level response to PKE

Pasture production, milk production, body condition score (BCS), 6-week in-calf rate, and not-in-calf rate were measured for each treatment.

Average milksolids production (kg MS/ha) was 16 percent lower in the 'Pasture treatment' (915kg MS/ha) when compared with the 'PKE treatment' (1092kg MS/ha). This was due to the combined effects of a lower stocking rate (0.2 to 0.3 cows/ha), lower average production/cow/day (0.08kg MS/day), and a shorter average lactation (seven days). There was no significant effect of treatment on BCS, 6-week in-calf rate or not-in-calf rate.

There was a large milk production response to PKE in all three years of the experiment. The PKE treatment cows produced an average of 122g MS/kg DM of supplementary feed (119, 106, and 140g MS/kg DM in 2015/16, 2016/17 and 2017/18 seasons, respectively).

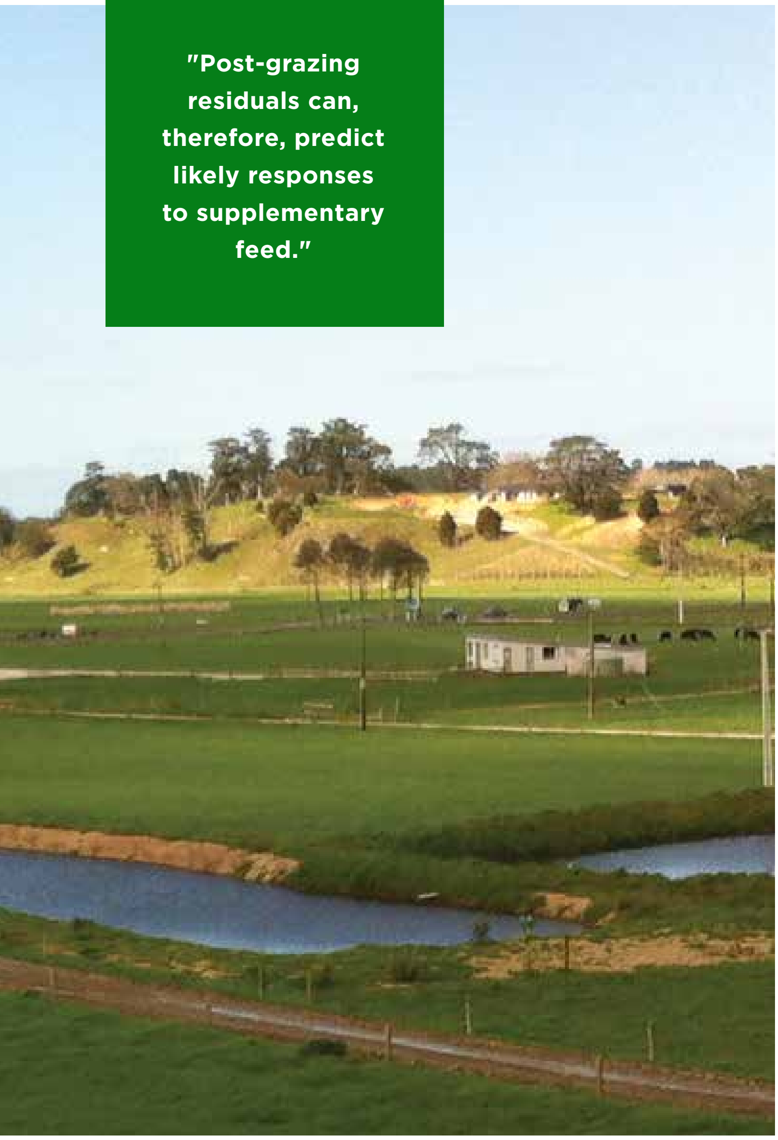
This response is approximately 30 to 50 percent greater than average milk production responses to supplementary feed achieved in historic multi-year farm systems experiments[2], as well as those estimated from farm financial databases[6].

It is difficult to isolate the cause of this comparatively large response to supplementary feed; however, several factors may have contributed, as detailed below.

Grazing management

The extra milksolids that can be expected from each kilogram of supplementary feed is primarily determined by the amount of pasture a cow 'refuses' when offered supplementary feed. This is referred to as 'substitution'[8, 9].

The rate of substitution is primarily determined by the relative feed deficit of the cow, which is a measure of how well the consumed diet meets cow requirements.



"Post-grazing residuals can, therefore, predict likely responses to supplementary feed."

For example:

- the lower the pasture allocation, the less pasture (energy) a cow will consume
- the less pasture a cow consumes, the less pasture she will refuse when offered supplementary feed (i.e. the lower the substitution of supplement for pasture)
- the lower the substitution, the greater the total feed intake, and the greater the milk production response to the supplementary feed.

In the Northland experiment, supplementary feed was offered only when post-grazing residuals were less than target (4cm, approximately 1600kg DM). Post-grazing residual can be used as an approximate measure of the relative feed deficit, with lower-than-target residuals indicating that cows could eat more, and higher-than-target residuals indicating greater substitution and potential pasture wastage. Post-grazing residuals can, therefore, predict likely responses to supplementary feed. For example, responses to supplementary feed decline by 10 percent for every 1cm increase in post-grazing residual[10].

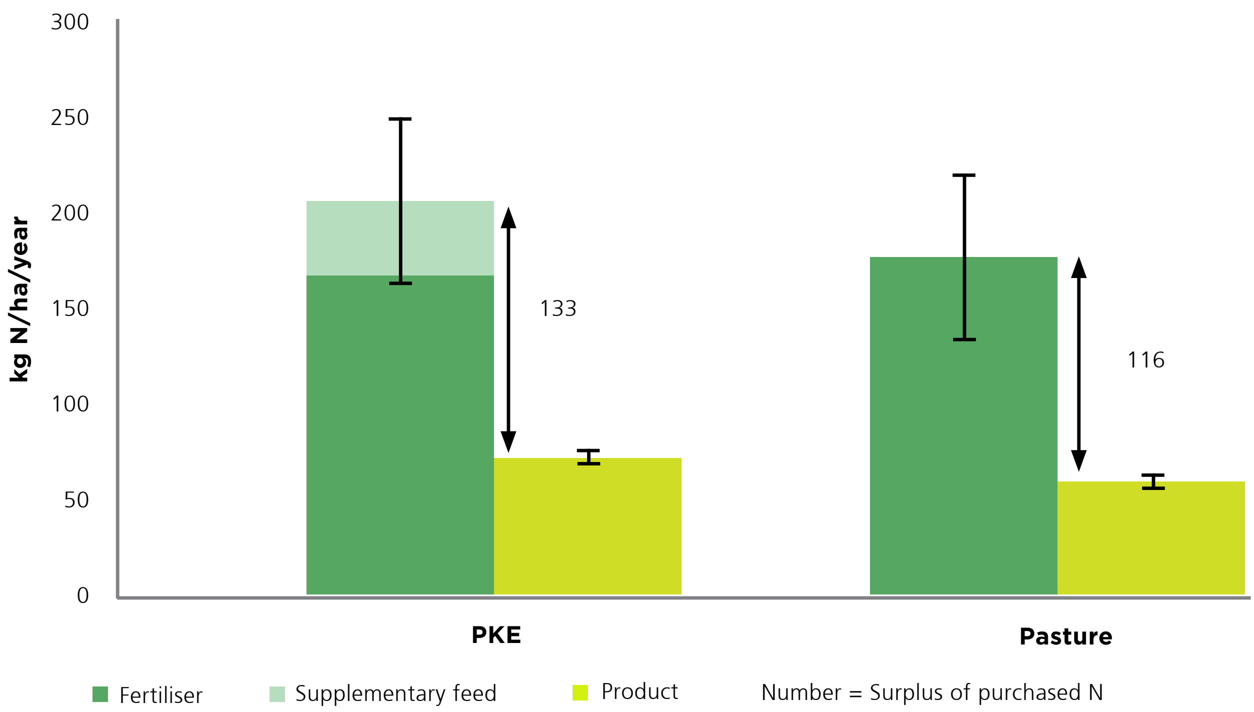
The decision rules around pasture management, and when and how much supplementary feed was offered in the Northland experiment, likely reduced pasture wastage and maximised the potential response to supplementary feed.

Milking frequency

Throughout the experiment, once-a-day (OAD) milking was a management strategy that could be used in both farmlets to

Cows from the 'Pasture treatment' herd. Photo: Northland Dairy Development Trust.

Figure 1. Effect of treatment on surplus of purchased N* (kg N/ha/year)



Error bars indicate ± standard deviation.
*Surplus of purchased nitrogen = N inputs as fertiliser and supplementary feed minus N output as product.

offset the negative consequences of a large feed deficit (e.g. energy balance and BCS).

In the third year of the experiment, high rainfall and saturated soil conditions led to very poor pasture production and utilisation during early spring. As a consequence, in the PKE treatment, cows were fed additional PKE to increase feed supply, while in the Pasture treatment, cows were milked OAD for six weeks. Milking cows OAD in early lactation has a negative, immediate and carry-over effect on milk production, due to reduced mammary cell activity and number[11].

The negative effects of OAD milking on immediate and whole-season production likely contributed to the greater response to supplementary feed that occurred in the third year of the experiment (140g MS/kg DM). This inflated the average response to supplementary feed at a farm systems level.

Pasture species

This experiment was conducted in Northland with kikuyu forming a seasonal component of the pasture sward. Kikuyu has a lower DM digestibility than ryegrass pastures. A cow grazing kikuyu-dominant pastures will consume a lower quantity of metabolisable energy and, potentially, be in a greater relative feed deficit, compared with a cow grazing ryegrass pastures for the same DM intake. As a result of the greater relative feed deficit, a larger response to supplementary feed could be expected from cows grazing kikuyu-based pastures than ryegrass pastures.

Environment

The effects of the different treatments on the environment were modelled through Overseer version 6.3.1.

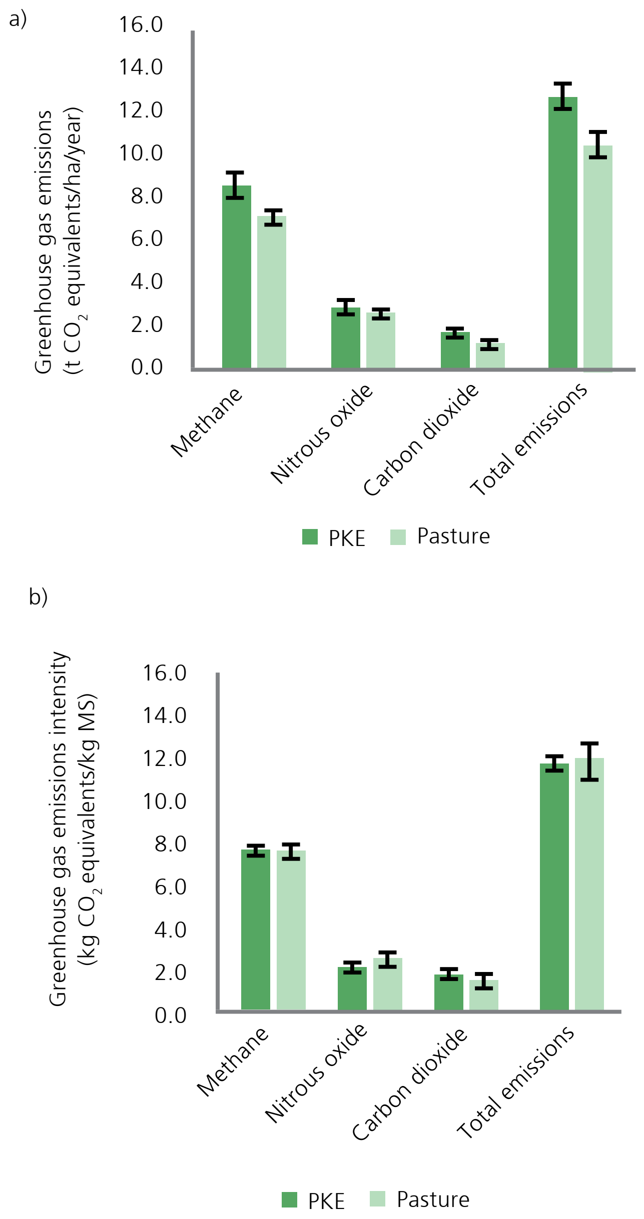
There was no significant difference in nitrogen (N) surplus (*Figure 1*) and, as a result, no effect on estimated N leaching between the PKE (16.3kg N/ha/year) and Pasture (15.7kg N/ha/year) treatments.

However, in contrast, GHG emissions were 15 percent less in the Pasture treatment relative to the PKE treatment (11t of CO_2 equivalents/ha/year and 13t CO_2 equivalents/ha/year, respectively – see *Figure 2*).

These differences were largely the result of lower methane emissions/ha associated with lower total feed eaten (DM intake/ha) in the Pasture treatment. The contribution of CO_2 to total GHG emissions also tended to be lower with the removal of PKE due to the off-farm carbon footprint associated with PKE (kg CO_2-equivalents/kg DM).

There was no effect of treatment on emissions intensity (kg CO_2-equivalents/kg MS – see *Figure 2*), which is consistent with previous studies investigating the effect of feed use on GHG emissions[7].

Figure 2. Treatment differences in methane, nitrous oxide, carbon dioxide, and total emissions



Error bars indicate ± standard deviation.

Profitability

Financial data from the experiment were analysed to determine the average operating profit for each treatment, including a non-cash adjustment for differences in capital requirements between treatments.

In addition to the three-year financial analysis, economic modelling was undertaken to account for changes in milk and key input prices and to evaluate the likely long-term profitability of the two treatments.

About 100 farmers attended a 'Reducing Reliance on Imported Feed Trial' field day at the Northland Agricultural Research Farm in 2018. Photo: Northland Dairy Development Trust.

An average milk price of \$6.16 (± \$1.54/kg MS) and PKE price of \$287 (± \$47/t) were used in the analysis (± standard deviation).

On average, gross farm revenue was 16 percent less (\$1129/ha) in the Pasture treatment, relative to the PKE treatment. However, average operating expenses were also 17 percent (\$831/ha) lower in the Pasture treatment relative to the PKE treatment.

Similar to the conclusions of previous studies[2, 3, 5], increased expenditure on imported supplementary feed was associated with a more-than-equivalent increase in total expenses. In the Northland experiment, for every \$1 spent on imported supplementary feed-related expenditure, total operating expenses increased by an average of \$1.89.

As a result of net differences in gross farm revenue and operating expenses, the PKE treatment returned only a small average operating profit advantage of $150/ha (seven percent) compared with the Pasture treatment (see *Table 1*). When accounting for the variability of key market prices, such as milk and palm kernel, the PKE treatment returned a greater operating profit in approximately 70 percent of scenarios (also see *Table 1*).

The relative profitability of the treatments was highly sensitive to the response to supplementary feed. The response to supplement in the current study was 30 to 50 percent greater than average responses previously reported from farm systems experiments and farm financial benchmarking databases.

A 10 percent lower milk production response to supplementary feed would erode any profit advantage from feeding PKE (*Table 1*). In other words, even with a response of 110g MS/kg DM, over a decade, the PKE and Pasture treatments would return a similar average operating profit.

Despite the large responses to supplementary feed achieved in the current study, if an economic valuation of treatment differences in GHG emissions (at $25/t CO_2 equivalents) was considered, the average profit advantage of the PKE treatment over the three-year period of the experiment was reduced to $89/ha. In addition, the PKE treatment would then return a greater operating profit than the Pasture treatment in only 55 percent of years.

Table 1. Effect of response to supplementary feed on treatment differences in profitability

Treatment comparisons	Response to supplementary feed (g MS/kg DM)		
	122	110	75
Average profit advantage of 'PKE treatment' relative to 'Pasture treatment' ($/ha)	$150	$0	- ($230)
Probability that 'PKE treatment' will be more profitable than 'Pasture treatment'	70%	50%	10%

Conclusion

In summary, reducing the use of imported supplementary feed will likely reduce total feed intake, milk production, and GHG emissions per hectare. The effect on profitability depends on several factors, including the potential response to supplementary feed, milk and supplementary feed prices, and the extent to which total costs can be reduced with lesser quantities of imported supplementary feed.

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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[7]. 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[9].

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

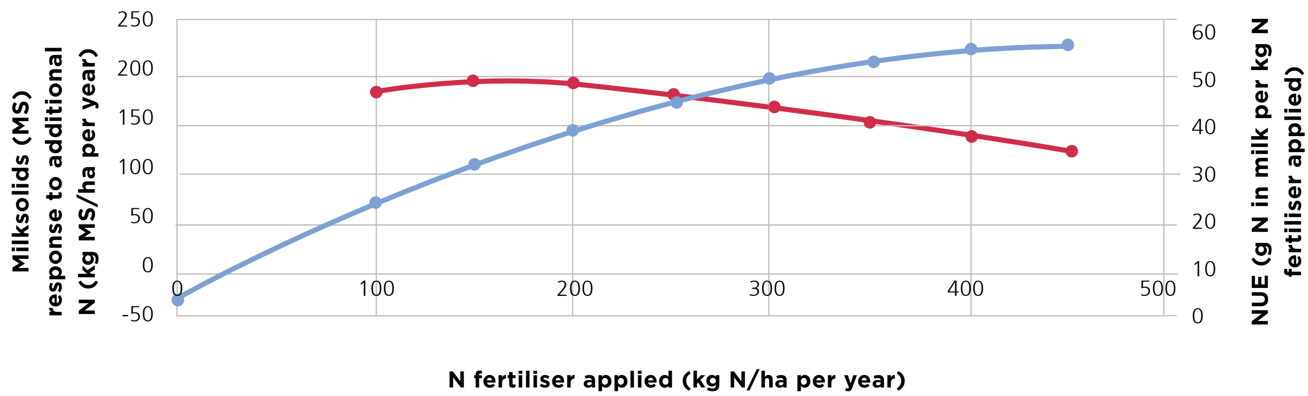
Increasing N use efficiency

Earlier publications have summarised good management practice for N fertiliser use, e.g. other DairyNZ *Technical Series* articles[10, 11] and DairyNZ's *Farm Facts* on plant nutrition[12]. A comprehensive overview is the *Code of Practice* published by the Fertiliser Association of New Zealand[13].

Here are some less well-known aspects of N fertiliser use[12, 13, 14, 15].

- 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*

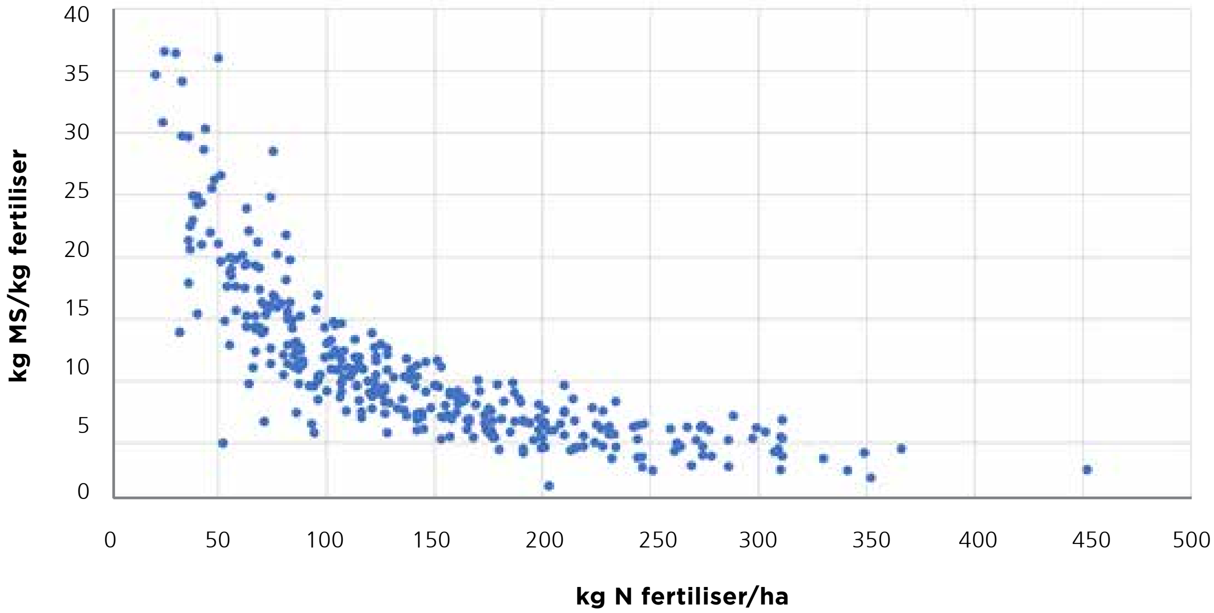


This graph indicates that milk production hardly responded to N fertiliser above 450kg N/ha.

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[8], 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, as mentioned on page 9) 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, AgResearch, Plant & Food Research, Lincoln University, Foundation for Arable Research and Manaaki Whenua – Landcare Research. See* **dairynz.co.nz/frnl**

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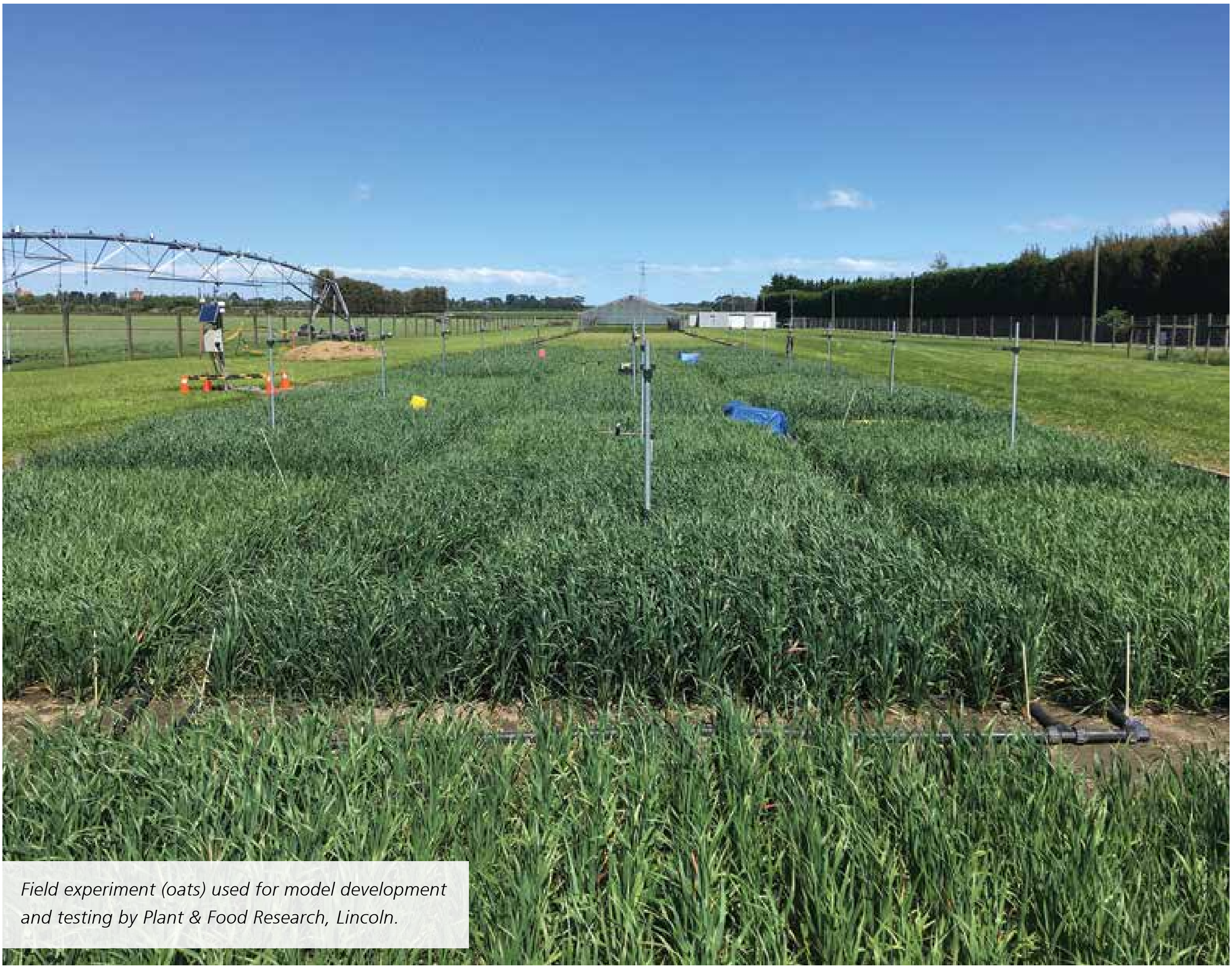
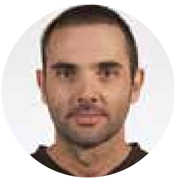


Field experiment (oats) used for model development and testing by Plant & Food Research, Lincoln.

The power of combining field trials and modelling

Combining field trial data with simulation models can offer new insights into complex plant-soil interactions, such as how catch crops perform under different locations, sowing dates and weather conditions.





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Gathering scientifically robust data from agricultural field trials is a vital step in understanding how biological, chemical and physical processes interact in the natural environment. Field experiments enable us to test and answer specific research questions through replication (multiple plots with identical treatments). This helps us gauge natural variability and the probability of obtaining a repeatable result.

However, results from specific field experiments cannot be immediately extrapolated to other management and environmental conditions. Key factors such as local climate, inter-annual weather variability, soil type and management can all influence the myriad processes that lead to a site-specific and time-specific result (e.g. crop yield).

This is where simulation models can help, by expanding our understanding of complex plant-soil-climate interactions. Detailed data from multiple trials can be used to develop and test computer models that represent plant and soil processes. The models can then, for example, be applied to determine effects using long-term historical weather data. Thus, we can predict the level of variability in crop performance from year to year (e.g. in dry, normal and wet seasons), as well as from different climates, soil types and management interventions.

Practical context: catch crops

An example of this synergy between field experiments and models is the recent catch crop work developed in the Forages for Reduced Nitrate Leaching (FRNL) programme*, which illustrates the added value of these approaches.

Winter grazing systems are inherently subjected to greater risk of nitrogen (N) leaching losses because of the large amounts of N excreted by grazing livestock onto bare soil during wet and cold months[1]. Recent field trial work has shown that sowing a catch crop of oats directly after winter forage grazing (i.e. in June, July or August) can significantly reduce the risk of N leaching. In addition, farmers can benefit from additional biomass production when oats are taken through to green-chop silage maturity (50 percent ear emergence) or beyond[2, 3].

This reduction in N leaching is because some of the N is taken up by the crop biomass, instead of leaching when drainage events occur[4, 5]. For example, a recent field trial in Lincoln, Canterbury, showed that sowing oats in July or August reduced total mineral N (nitrate-N + ammonium-N) leaching losses by 33 to 44 percent compared with a conventional fallow (bare soil) situation (*Figure 1*).

In *Figure 1*, we can see the importance of time of sowing and seasonality of weather events affecting both N leaching and crop growth. Note the degree of monthly variability, and the reductions in N leaching occurring from early spring (September), mainly when oats were sown in July (green bars). These conditions are unlikely, for environmental and operational reasons, to be the same every year.

So, how much could the benefits of catch crops differ under contrasting locations, sowing dates and weather conditions? To help clarify this, we applied the Agricultural Production Systems sIMulator-NextGeneration (APSIM-NextGen) model platform[6] to

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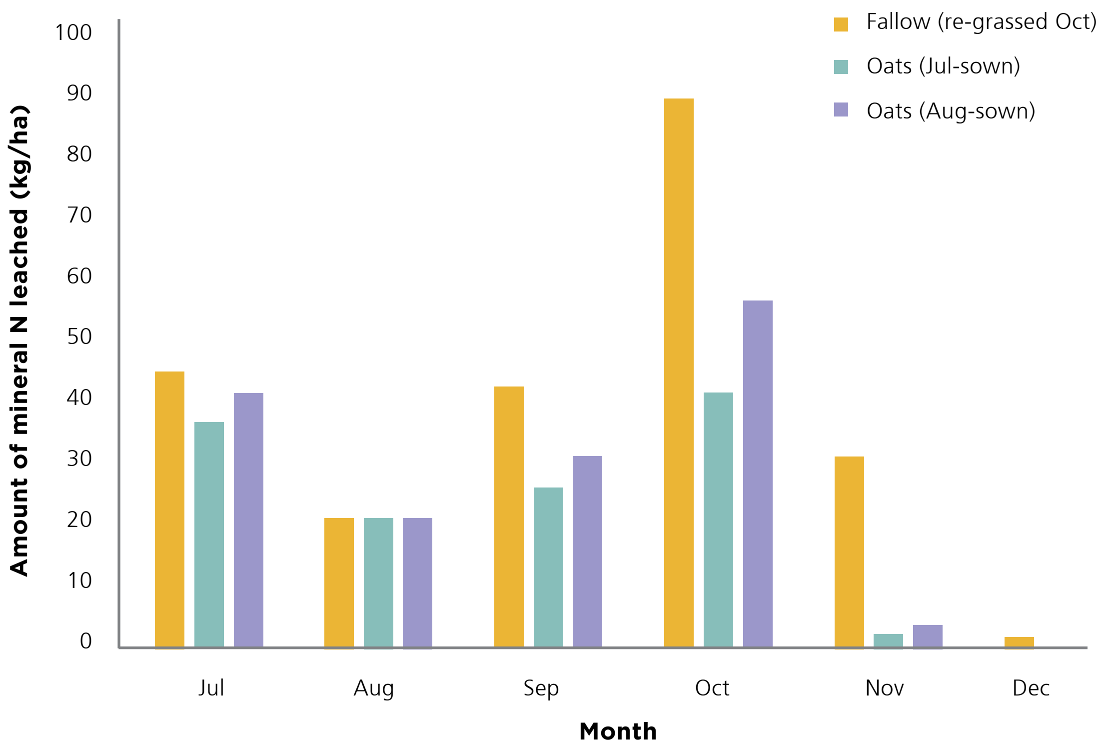
Figure 1. Monthly amount of mineral N leached from a stony soil after urine application (300kg N/ha in July) and July- or August-sown oats, compared with conventional fallow



test how winter-sown catch crops might perform under a diverse set of conditions. Newly developed fodder beet and oat models were set up in APSIM-NextGen that allowed simulation of winter forage-catch crop rotations over consecutive climate years and across different locations.

How models function

Agricultural systems models come in a variety of types, reflecting different uses and needs. Computer models combine information to help us understand a given process or system. This then enables us to estimate how the process or system responds if conditions change. So, the more we know about the system, the more robust the model, and the better the model predictions will be.

Model results are used to infer how much we know about the system and help guide new studies. They also allow us to extrapolate experimental findings to other locations and conditions. Models can also be used to devise recommendations about management practices or, potentially, to aid directly with on-farm decision-making.

Models are always a simplified (partial) representation of the system to tackle a specific question and, therefore, are useful only for the particular purposes for which they were originally designed. This is because agricultural systems are both complex and dynamic. It is virtually impossible to collect and consider all data at experimental or farm level, so computer models provide the environment to integrate and make sense of vast quantities of information.

Models take into account a limited amount of detail of a system; thus, selecting an appropriate one is highly important[7]. This is why models must be constantly tested against measured datasets and updated to ensure they perform adequately for the given purpose.

New insights by combining data and models

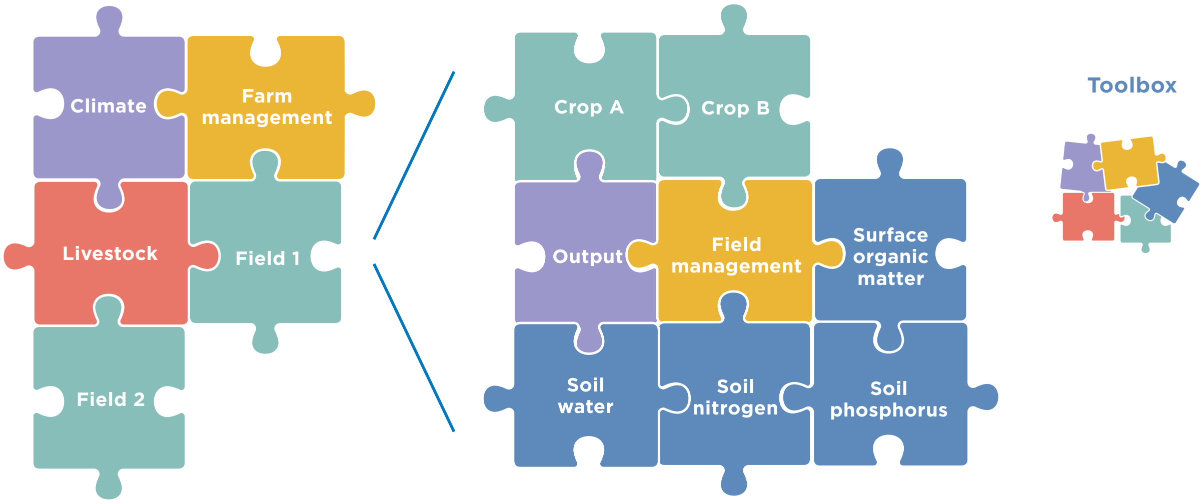
In FRNL, an APSIM-NextGen model (*Figure 2*) was used to represent a sequence of fodder beet followed by an oats catch crop. Modelling took into account weather conditions over 25 years (1975 to 2000), four climatic zones and catch crops sown in four months (June to September). *Table 1* shows the simulated reduction in N leaching at 80cm soil depth by the presence of an oat catch crop instead of a fallow (bare soil) condition.

Our simulation results show oat catch crops could effectively reduce N leaching in all four regions, but results largely depended on weather conditions (particularly rainfall timing and intensity). This expands knowledge gained from our field experiments. The results provide an estimate of gains from early sowing, when operational conditions allow.

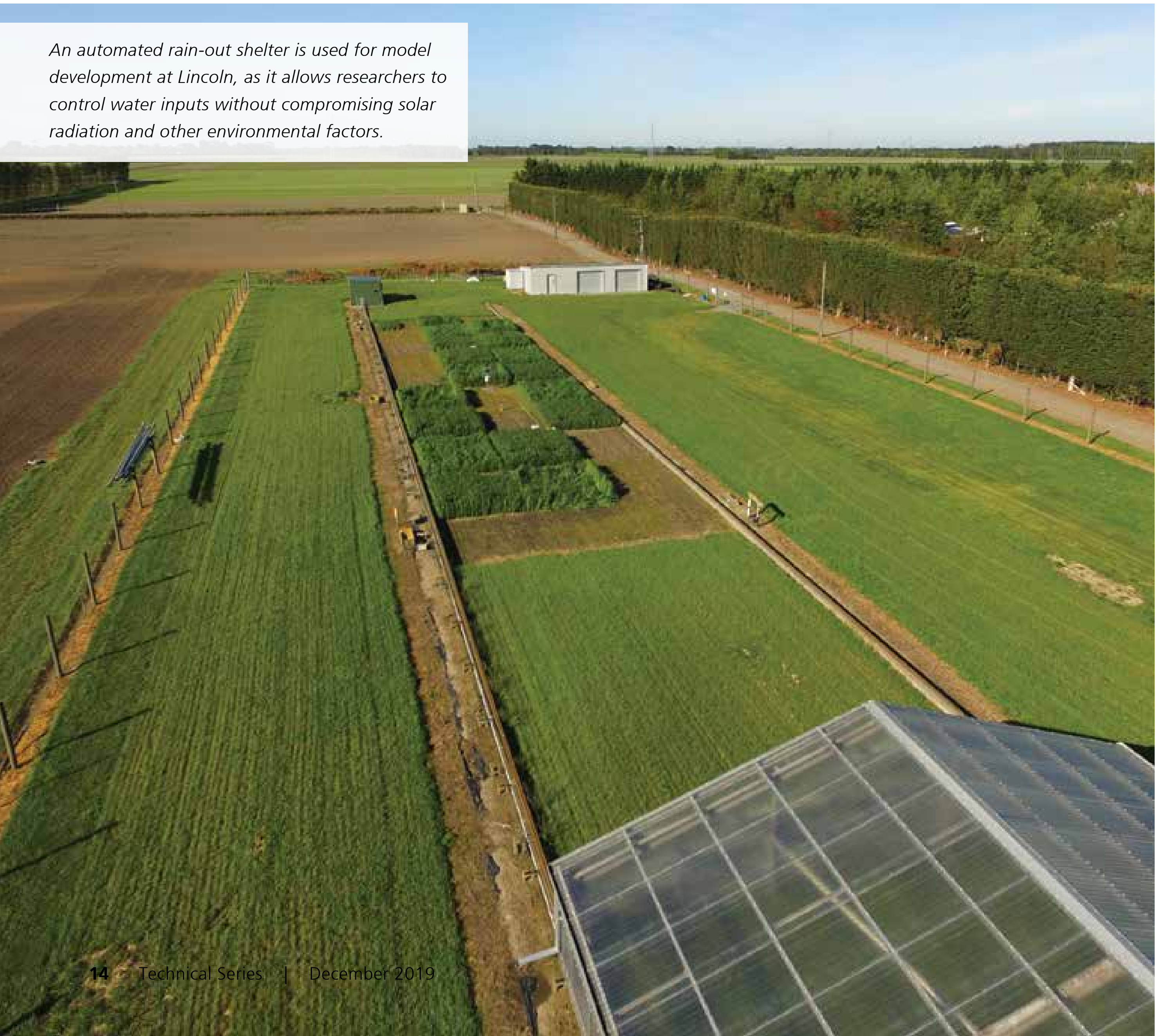
The model results give us a quantitative basis to evaluate the cost/benefit of management options, and to understand seasonal variability, which are useful to inform on-farm decisions. For example, although median values of N leaching reduction for Canterbury were approximately 41 percent, unfavourable weather years can result in values as low as 10 percent, while

Catch crop sowing date trial at Plant & Food Research, Lincoln. The trial compared ryecorn vs oats, sown in July and August 2016.

Figure 2. A conceptual representation of APSIM-NextGen



Note: The farm and each field (left) are built from a combination of models found in the toolbox (right). The APSIM-NextGen infrastructure connects all selected model pieces together to form a coherent simulation[8].



An automated rain-out shelter is used for model development at Lincoln, as it allows researchers to control water inputs without compromising solar radiation and other environmental factors.

up to 65 percent was estimated for favourable weather conditions. This represents a large year-to-year variability and highlights the extra information that models can provide. It also indicates that future work is needed to identify actions that can be taken for conditions where catch crops are limited in their effectiveness.

Conclusions

In the context of winter-sown catch crops, using modelling has helped us to quantify the importance of inter-annual variability, timing of sowing and location differences in how effective catch crops can be to mitigate N leaching.

For farmers, this implies that, weather and operational

Catch crop cereal species trial at Plant & Food Research, Lincoln. The crop was sown in June 2017, and yields were measured at various maturity stages: green-chop, whole crop and grain.

Table 1. Simulated paddock-scale N loss reductions by oat catch crops relative to fallow conditions after grazed fodder beet on a low-water-holding-capacity soil

	Southland			Canterbury			Hawke's Bay			Waikato		
Sowing date	Low rain¹	Mid rain²	High rain³	Low rain¹	Mid rain²	High rain³	Low rain¹	Mid rain²	High rain³	Low rain¹	Mid rain²	High rain³
June	25%	22%	29%	65%	41%	35%	41%	20%	27%	34%	34%	23%
July	22%	17%	27%	53%	33%	30%	31%	7%	22%	28%	27%	14%
August	12%	8%	19%	41%	26%	23%	18%	4%	11%	20%	19%	7%
September	5%	0%	3%	18%	14%	10%	0%	2%	3%	12%	6%	2%

¹≤25th percentile of long-term average rainfall; ²>25th percentile and <75th percentile; ³≥75th percentile.

Note: colours correspond to different ranges of effectiveness.

0-5% 6-10% 11-20% 21-30% 31-40% 41-50% 51-60% 61-70%

conditions permitting, there is great value in sowing catch crops as early as possible after the grazing events because reductions in N leaching are of greater magnitude. Annual/seasonal weather conditions (e.g. amounts and timing of rainfall) will largely influence catch crop effectiveness, with both good and challenging years, so outcomes are better appreciated over multiple years.

Finally, this catch crop work illustrates the power of linking field trials with agricultural systems models. The synergy between field experimentation and modelling can and will be used in future to help answer other research questions.

** This research was completed as part of the Forages for Reduced Nitrate Leaching programme with principal funding from the Ministry of Business, Innovation and Employment and co-funding from research partners DairyNZ, AgResearch, Plant & Food Research, Lincoln University, Foundation for Arable Research and Manaaki Whenua – Landcare Research. See* **dairynz.co.nz/frnl**

KEY POINTS

- Field trials generate valuable experimental data for understanding agricultural system responses under 'close to reality' conditions.
- These experimental data can then be used to build models that represent, in a simple way, aspects of 'real world' systems to address specific questions.
- Linking field data and modelling for winter-sown catch crops has unveiled the importance of inter-annual variability, timing of sowing and climate on N leaching mitigation.

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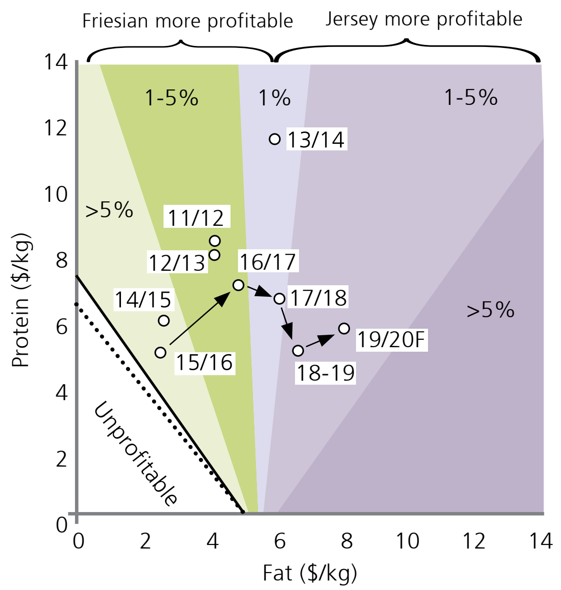
Fat price affects breed profitability

With milk fat now worth more than protein, how do Jersey and Friesian cows compare for profitability? Find out from DairyNZ senior scientist Paul Edwards.

The value of fat relative to protein has risen significantly since 2016. Fat almost reached parity in 2017/18[1] and, by 2018/19, was worth more than protein. That raises the question of how different breeds now compare in terms of their relative profitability.

In *Technical Series* June 2019[2], we summarised the results of an experiment comparing Jersey (J) and Friesian (F) cows at a comparative stocking rate of 80kg body weight/t DM of feed (CSR80), the optimum stocking rate for farm profitability[3]. This was equivalent to a stocking rate of 3 (F) and 3.6 (J) cows/ha in this experiment.

Figure 1. Effect of fat and protein value on relative profitability of Jerseys and Friesians



Shaded ranges mark where the profitability of breeds are within one percent, are one to five percent, or more than five percent greater than the other. Friesians are more profitable on the left and Jerseys on the right. Actual fat and protein prices from 2011/12 through to 2019/20 (forecast) plotted as circles.

J produced more fat/ha and similar protein/ha (see June article for actual numbers); however, due to the higher proportion of fat, each kg of milk was worth 9c/kg less[4], based on $4.41/kg for fat and $8.02/kg for protein. Combined with differences in operating expenses/ha (due to a greater number of cows), this resulted in J being less profitable than F.

Given fat's recent value increase, we performed a sensitivity analysis to determine the effect of fat and protein prices on the relative profitability of J and F[5]. Due to differences in milk composition, we also applied a seasonal volume adjustment of 2.92c/litre, resulting in an adjustment of +$39/ha for J and -$47/ha for F. See *Figure 1* for results, which include milk prices since 2011/12.

J and F's profitability was equal at a fat price of $5.67 ±0.20/kg, depending on protein price, which had little effect due to the breeds' similar protein production (kg/ha). This fat price was the point where the value of J's additional production of fat offset its higher operating costs/ha. Including a peak volume adjustment could decrease the fat price, when the breeds are equal in profit, by a further 23c/kg. These results indicate the price levels (particularly for fat) at which J might be favoured over F (or vice versa) in pasture-based farm systems, assuming similar levels of other income and expenses to those in this study.

In the last decade, the price of fat has generally favoured F. However, it has favoured J since 2017/18, and fat's value relative to protein is likely to keep rising in the medium term given processors calculate milk component prices on a rolling average. However, breeding is a long-term decision, so farmers should consider the medium- to long-term outlook for fat price when choosing between these two breeds.

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