Finding ways to reduce nitrogen (N) leaching, while sustaining production and profit, is a challenge facing 50 scientists working on the Forages for Reduced Nitrate Leaching (FRNL) programme.

The six-year project combines expertise and resources from six organisations – DairyNZ, AgResearch, Plant & Food Research, Landcare Research, Lincoln University and the Foundation for Arable Research.

Dairy, arable (crop) and sheep and beef farms are also involved in the cross-sector project which is focusing on three areas – alternative pasture species, crops and farm systems. Nine farmers are contributing to the direction of the research by monitoring their farms for five seasons.

Information collected includes daily grazing and supplementary feed records, application levels of effluent, fertiliser and irrigation and stock and feed movements. This will help determine the effects of management on crop and pasture yield and quality, the farm’s nutrient budget, and profit.

Dairy pastures frequently contain a higher concentration of N than dairy cows require, and most of the excess is excreted in urine. Urinary N is concentrated in a small area and is more than plants can use, so much of it is prone to leaching into the ground water. Some enters waterways, posing an environmental threat.

The FRNL scientists are looking at ways to develop pasture and cropping systems that are more efficient at reducing N in urine and at capturing N from the soil.

Three scientists, John de Ruiter and Edmar Teixera at Plant & Food Research; and Garry Waghorn at DairyNZ are working on different, but inter-linked areas of crop research for the FRNL programme.
Finding low N forages and feed

At Plant & Food Research, John de Ruiter is analysing data on a wide range of feeds to identify relationships between forage type, nutritive value and crop management. The aim is to find low N forages and conserved feeds with high fibre or high total carbohydrate content that may lower urinary N excretion when fed. So far, more than 3000 entries have been analysed.

John is checking what’s out there in terms of different crops, their chemical composition, how they metabolise and what adjustments to quality can be made by using specific crop management practices on-farm. These include variables like cultivar choice, time of sowing, fertiliser and irrigation effects, and how all of these might affect the composition of the plant. He is fine tuning the database to pick trends among forage types and identify regional differences.

Field trials in Waikato with rape, fodder beet, maize, chicory and oats have looked at different N and Potassium (K) application rates, and different sowing rates to see how quality varies. Similar plot trials in Canterbury compared fodder beet and kale with maize and cereals. When crops were managed for high yield, there was surprisingly little variation in the quality. When conditions are suboptimal for plant growth, the effects on quality were more pronounced.

New Zealand’s unique outside wintering system

New Zealand is unique in terms of wintering cows on crops, unlike many other parts of the world where animals are often fed inside and where there is opportunity to collect effluent.

“High yielding crops are more cost effective. But the higher the yield, the higher the stocking density and the higher the amount of N return per unit area in the paddock. Reducing the yield target is one option to reduce N loading, but a more sensible option might be to manage or select feeds that achieve lower urinary N concentrations. We could adopt cut and carry systems or feed crops for shorter periods and then move stock to standoff areas. I think a mix of these approaches may be required for best economic use of standing feed and with lower environmental impacts,” says John.

Crops to ‘mop up’ N

Plant & Food researcher Edmar Teixera is running a series of computer simulated experiments to test the impacts of different management practices – in this case sowing dates – on N leaching.

Latest research shows that although the effect of winter cover crops such as Italian ryegrass or oats are often positive, the magnitude of leaching reduction varies from one year to another. To understand the causes the Plant & Food Research team is modelling various scenarios.

“With the model, it is possible to simulate the effect of different management options (e.g. contrasting cover crop sowing dates) and soil types across multiple years,” says Edmar.
30 years weather data used

“We used 30 years of historical weather data from Lincoln to predict the impact of weather variability on cover crop production,” he says.

“There are some strong trends emerging. First, management is very important. The later you sow, the less effective cover crops are. They have less time to grow, therefore less time to take up N. “Intuitively, we know this, but the model gives us a better measure of the benefits and the risks involved when multiple factors, e.g. differing cover crops, sowing timings, variable weather, N loading from previous crops and crop management (irrigation and fertiliser) are in play,” says Edmar.

Cover crops significantly reduced N leached on soil types with both high and low water holding capacities. So even on leaky soils, the cover crops were taking up a significant amount of N. The researchers also learnt that environmental conditions, particularly the amount and timing of rainfall events, influence both leaching events and cover crop growth.

Field trials begin

The outcomes from this first year’s modelling work are being validated in a field experiment at Plant & Food Research, Lincoln, looking at establishing N ‘mop-up’ crops during winter. With Brendon Malcolm from the Field Crops team, the researchers are now testing the timing of sowing oats following the grazing of winter forage kale. Edmar says the modelling and the field work complement each other.

“This work will provide a better estimate of cover crop benefits and give farmers additional management options to reduce the risks of N leaching,” says Edmar.

The FRNL programme, which runs until 2019, has just finished its first season. Initial results show that the programme could offer a realistic path to reducing the environmental impact of dairy farming and bring long-term economic benefits to New Zealand.

Forages for Reduced Nitrate Leaching is a DairyNZ-led programme in partnership with AgResearch, Foundation for Arable Research, Landcare Research, Lincoln University and Plant & Food Research. The principal funder is the Ministry of Business, Innovation and Employment; all partners co-fund the programme.

Fodder beet a low N feed option

Research at DairyNZ led by senior scientist Garry Waghorn, has measured the fate of dietary N in cows in late lactation (March) and dry cows (May) by feeding them diets including fodder beet. Urine and faeces was collected to measure N content.

PhD student Elena Minnee was involved with the trial and grew the fodder beet.

Fodder beet was fed with ryegrass pasture to lactating cows, and fed with either barley straw or pasture silage to dry cows. Fodder beet can yield 30 T dry matter (DM)/ha, and about 20 percent of the DM is in leaf and the rest bulb. The leaf has a similar N content to pasture, but the bulb has very low concentrations of N, very little fibre and high concentrations (63 percent) of readily fermentable carbohydrates (‘sugars’) that can cause acidosis if cows are not adapted or too much is fed. The concentrations of calcium, phosphorus and sulphur are very low in bulbs.

Table: Composition of pasture and fodder beet fed to the lactating cows (% of dry matter).

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<th>Pasture</th>
<th>Fodder beat</th>
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<tr>
<td></td>
<td>N (CP)</td>
<td>Leaf</td>
<td>Bulb</td>
<td></td>
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<tr>
<td>N (CP)</td>
<td>3.1 (19)</td>
<td>2.4 (15)</td>
<td>1.1 (7)</td>
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<tr>
<td>Fibre</td>
<td>52</td>
<td>33</td>
<td>11</td>
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<td>Phosphorus</td>
<td>0.34</td>
<td>0.18</td>
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<td>Sulphur</td>
<td>0.34</td>
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* Leaf was 25% of fodder beet in March and 16% in May.

Both trials used 16 cows. They were held in stalls for 10 days and fed different mixtures of pasture and fodder beet. Samples were taken of the diet during digestion, and faeces and urine were collected separately. The dry cows given 70 percent beet with 30 percent silage remained healthy, but 85 percent beet with 15 percent barley straw resulted in sick cows, because the rumen pH dropped too much (acidosis). Their fodder beet was decreased and half were removed from the trial.

These measurements showed cows in late lactation should not be given more than 50 percent fodder beet in their diet with pasture but dry cows can be fed 70 percent fodder beet. Fodder beet is a high yield, low N feed which, in the right combination with other feeds, can be a useful winter feed option.