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Minimising nitrate loss to water from over-winter forage crops at Mangakino

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1. Executive summary

The field work reported here was funded by DairyNZ, Ballance Agri Nutrients and LTPT (Lake Taupo Protection Trust) and conducted on the property of WMI (Wairarapa Moana Incorporated) at Mangakino. It was carried out in the context of a larger systems project whose objective is to investigate and develop winter management systems that minimise nitrate leaching from dairy farming, especially over the winter. This is a key period of sensitivity and could potentially impact on efforts to intensify (dairying in particular) and "freedom to operate".

The first of the two years of field work has been completed. The aim of this work was to field test the risk of nitrate leaching from the management of over-winter forage fed to dairy cows and to start to develop management strategies to minimise this risk. Although the use of over-winter forage (as opposed to pasture) might be a useful management tool for benefitting production, little is known about the associated environmental risks and, importantly, how these might be managed

A kale/swede forage crop (c. 7 t DM/ha) was grazed in June by a mob of c. 400 dairy cattle. Subsequent nitrate-N losses were 114 kg N/ha from the grazed forage crop, and were decreased by DCD application applied immediately after grazing and repeated 6 week later (87 kg N/ha). Nitrate leaching was also measured in an area of the crop fenced to exclude animals and harvested by hand. Nitrate-N loss over the winter from this ungrazed patch was 60 kg N/ha. Thus, c. 52% of the winter leaching was attributable to growing a forage crop and then leaving the soil bare over winter after its removal; by difference, therefore, about 48% of the N loss could be attributed to excreta/urine deposition.

These preliminary results indicate risk of nitrate leaching from winter grazing forage crops in situ, but also significant benefit from use of a nitrification inhibitor in this situation. The results demonstrate various strategies are available to decrease N leaching from forage crops:

- *Grow a good forage crop* – A well grown, high yielding, crop will use this soil N supply; the less nitrate sitting in the soil in autumn, the better in terms of leaching risk.
- *Use a nitrification inhibitor* – Once the crop has been grazed, the aim should be to stop urine-N converting to mobile nitrate-N that can be leached out of the soil.
- *Delay grazing?* – The earlier that urine is deposited on the ground in autumn/winter, the greater the amount of subsequent rainfall and leaching.
- *Feed the forage crop elsewhere?* – Cut and carrying to a feedpad, combined with being able to spread the effluent in periods of low leaching risk would be of benefit, but may be an expensive option for many.

The work is being repeated for a second year after which we will be carrying out further whole farm systems analyses with an end objective of:

- Developing some sort of “ready reckoner” to enable WMI farmers to evaluate wintering options to minimise nitrate leaching
- Make the information available to all farmers at a public field day and through other extension mediums

The LTPT funding was obtained after DairyNZ and Ballance Agri Nutirients had committed to the project and has added value by supporting the collection of additional measurements from the field work and by extending technology transfer opportunities.

2. Background

Over-wintering cattle on forage crops has been an established management technique on the South Island for a number of years, mainly because the cool winter temperatures reduce the amount of pasture available during this period. However, as the drive for increased productivity continues, the approach is now being adopted on the North Island. This trend may continue into the future and has implications for N leaching losses.

Despite the widespread uptake of the technique, there has been surprisingly little work done on the nitrate leaching risk and management strategies for reducing these losses. We could hypothesise that the leaching risk from such a system will be influenced by:

- Large amount of N accumulated in the forage crop before grazing, e.g. a 15 t/ha DM crop could contain 400- 450 kg/ha N.
- Grazing of the crop and subsequent urine deposition by the mob
- Bare soil thereafter for the remainder of the winter and through early spring until the following crop or reseeded pasture establishes

Monaghan et al. (2007) undertook an analysis of water quality data from the 2480 ha Bog Burn catchment in central Southland and linked this to land management activities. Focusing only on the dairying component of the catchment, the analysis indicated that the wintering part of dairy systems made a disproportionately large contribution to annual N losses (c. 60% of the losses from dairy), despite representing a relatively small area of the farming system (<15% of the dairying area). This was attributed to the factors described above.

The only New Zealand field work reported in the literature to date was undertaken on hydrologically isolated experimental plots with simulated grazing (Smith et al., 2008). Surprisingly, in the single year of this experiment, most of the annual leaching (79 kg/ha out of 96 kg/ha N loss) occurred during a wet summer when the forage crop was growing. Nevertheless, there was still substantial N loss after grazing in winter (26 kg/ha N) and work is ongoing at this site. A key finding was that the use of a nitrification inhibitor, Dicyandiamide (DCD), after grazing (to hold the urinary N in a less mobile ammonium form rather than the mobile nitrate form) halved N losses post-grazing. It also benefited other aspects of the N cycle by decreasing emissions of the greenhouse gas nitrous oxide.

Whilst these results are encouraging, it is worth noting that the work to date has focused on experiment plots and simulated grazing. The aim of our work was to extend the approach into a working farm system, i.e. measuring N losses from paddocks with or without a DCD application. This gives us at least some information on whether the approach would be successful at the farm level.

There is some quantitative information available; the winter forage cropping scenario has been inserted into the OVERSEER® Nutrient Budgets model (*Overseer*). However, it is recognised that this is based on a relatively small evidence base and any further information generated from field experiments would be of value in supporting the updating of the model. *Overseer* is seen by many as an invaluable decision support (and regulatory) tool for developing farming systems that minimise N losses to water and thus requires the best underpinning information available.

It is essential, therefore, to gather more information on the leaching risk of winter forage management and the development of mitigation practices to reduce losses. For example, though DCD is the main mitigation being tested, it could be that delaying grazing or cut and carrying the forage crop could be better alternatives.

The work reported here is a critical part of a wider project funded by DairyNZ and Ballance Agri Nutrients in which we initially modelled a range of dairy farming systems. The emphasis was on wintering systems for managing nitrate leaching in free draining soil types. From the systems analyses, we identified promising wintering options, some of which are the subject of the field work reported here. When the field work is completed, we will rework our systems analyses to meet the project objectives: "To develop most suitable wintering options for more intensive dairy farming systems" and will present the results to the farming community.

2.1 The field experiment

Funding from LTPT allowed <u>additional</u> treatments to be imposed and <u>additional</u> measurements to be made on the existing field experiment.

Wairarapa Moana Incorporation (WMI) and AgResearch have secured funding for the main farming systems project from DairyNZ and Ballance Agri Nutrients, which covered winter 2008 and runs through to May 2010[1]. The overall objective of this core project is to improve the knowledge and practices that allow intensification of dairy farms, yet at the same time limit nutrient loss to levels below future regulatory requirements.

A part of the overall project comprised a field experiment during winter 2008, which measured nitrogen leaching from an over winter forage crop, with the aim of recommending a mitigation strategy to decrease losses.

For this field experiment, 3 treatments were originally planned: brassica forage crop grazed in winter crop with and without DCD application after grazing; and a grazed pasture crop in an adjacent paddock for comparison.

Funding from LTPT allowed <u>additional</u> treatments to be included:

[1] Funding for a second year of the experiment by DairyNZ and Ballance Agri-Nutrients has since been confirmed

- Include a DCD treatment on the pasture (original proposal: no DCD on pasture) - the experiment provided a good opportunity to look at the options for controlling N loss from pasture and provided a more balanced experimental design.
- Keep a forage crop area that was ungrazed and monitor N losses from this area. This would advise us on the contribution of the cropping to overall leaching.

The benefits of support from the LTPT were, therefore, a more detailed and more robust field experiment on which to base recommendations, and additional technology transfer tailored for the Taupo catchment.

3. Objectives

Overall project objective: to improve the knowledge and practices that allow intensification of dairy farms, yet at the same time limit nutrient loss to levels below future regulatory requirements.

Specific objectives:

- Measure nitrogen leaching from a grazed and ungrazed forage crop
- Measure nitrogen leaching from an adjacent pasture paddock
- Test the effectiveness of DCD in decreasing nitrogen leaching from these paddocks
- Report the results to the wider farming community

4. Experimental approach

4.1 Overview

The field sites were established on the property of WMI Pouakani, near Mangakino. During spring 2008, two paddocks were identified for the experiment: grazed pasture and a newly drilled forage crop of kale and swede. Figure 1 shows the sites. The soil-type was a freely draining ash over pumice (Oruanui sand).

Figure 1: Paddocks selected for the experiment; forage crop (left) and pasture (right)

Summer 2008 was exceptionally dry, with many forage crops failing because of the drought. However, we had selected a paddock that grew reasonably well and which added some additional growth in late summer/early autumn after welcome rain in April.

In each of the two paddocks (pasture and forage crop), 20 large plots (324 m^2) were marked out and instrumented with porous ceramic cups (Webster et al., 1993). Ten porous cups were installed on each plot to a vertical depth of 60 cm, installed at an angle of 45 degrees. This represented 100 porous cups per treatment.

For observational purposes, an additional, separate, area was fenced in the forage crop paddock and a further 50 samplers installed. The purpose of this area was to keep it ungrazed and remove by hand the forage crop at the time that the field was grazed. This would then provide information on the contribution to N leaching of the fodder crop alone, i.e. separate out the effect of urine deposition.

The paddock was grazed in late June (Figure 2) with cattle alternating between the brassica (c. 18 hours per day) and the adjacent pasture (c. 6 hours per day). DCD was applied to half the plots within 2 days of grazing being completed (12 kg/ha a.i.), and re-applied 6 weeks later.

The forage paddock remained fallow after grazing until it was cultivated in August and Triticale drilled in early September. Monitoring of nitrate leaching continued through to the end of winter drainage in October.

Figure 2: Forage crop being grazed off in June

4.2 Treatment summary

Paddock 1 (kale/swede forage crop):

1. Grazed forage crop without DCD application
2. Grazed forage crop with DCD application (2 applications)
3. Ungrazed forage crop, with brassica physically removed from the plot at the same time that the rest of the paddock was grazed

Paddock 2 (pasture):

1. Grazed without DCD application
2. Grazed with DCD application (2 applications)

There were 10 replicates of treatments 1 and 2 within each paddock, in a randomised block design.

4.3 Measurements

4.3.1 Crop measurements

An approximate measure of the amount of dry matter accumulated by the forage crop was obtained by digging up the crop from 4 randomly selected quadrats (each 1 m^2 in area), drying the crop at 85 ^oC and weighing.

4.3.2 Soil measurements

Topsoil nutrient status was measured in spring (0-15 cm) to provide an indication of the background soil fertility of the site.

Soil mineral nitrogen (ammonium-N plus nitrate-N: Nmin) was measured at the following times:

- Prior to grazing in early June
- Mid winter, before the grazed forage crop was cultivated (July)
- At the end of the measurement period (October)

Measurement of Nmin is a useful indicator of the amount of nitrogen at risk of leaching, particularly when measured in autumn. It provides information to supplement the measurement of nitrogen leaching using porous ceramic cups, as detailed below.

4.3.3 Nitrogen leaching

Porous cups (60 cm deep) were used to measure nitrogen leaching from May-October. They comprised of a porous ceramic end, which was inserted to 60 cm depth down an augured hole, which was then backfilled with silica flour (to ensure good soil-ceramic contact) and soil. Samplers were installed at an angle (45 degrees to the vertical) so that the soil immediately above the sampler was undisturbed.

Their effectiveness in light-textured soils for sampling soil solution (by applying a vacuum to the sampler to draw in solution and then sampling the solution for chemical analysis) is well documented (e.g. Webster et al., 1993; Shepherd & Lord, 1993). There were two main operational challenges in using them in this experiment, however:

- Likelihood of large variation in N concentrations measured by individual samplers – this is a recognised problem in grazing situations where the concentrations will depend on whether the sampler is located under a urine patch or between urine patches. The advantage of the porous cup sampler is that they are relatively inexpensive and we installed 100 samplers per grazed treatment (i.e. 200 samplers each in the forage crop and pasture paddocks), plus an additional 50 samplers in the ungrazed ‘observation’ plot.
- Cultivation of the forage crop area post-grazing – because drainage was likely to continue after the next crop was drilled in August/September, it was necessary to remove the samplers before cultivation (to avoid destroying them). They were therefore re-installed after drilling, using the same technique. They did not, however, return to the soil in exactly the same position as prior to cultivation. This was not a problem on the grazed paddock where they were able to be left *in situ* all winter and spring.

To calculate loads of nitrogen leached (kg N/ha), measured concentrations were multiplied by soil drainage. Because the porous cups do not measure drainage, this drainage value was calculated using a soil-crop water balance model.

5. Results and discussion

5.1 Weather

2008 was a challenging year for growing and managing forage crops (and pasture). It featured a hot dry summer, with temperatures Jan-April greater than the long-term average and rainfall Jan-Mar *c.* 15% of the average (Table 1). April was exceptionally wet, as were July and August.

As a result of the very wet April (223 mm rain), we calculated drainage started in mi-April and was completed in mid-October, with 798 mm drainage in this period (Figure 3).

Table 1: Average air temperature monthly rainfall and soil temperature (10 cm), comparing 2008 with the long-term average (LTA) 1980-2000)

Month	Air Temp (^oC)		Rainfall (mm)		Soil Temp (^oC)	
	2008	**LTA**	**2008**	**LTA**	**2008**	**LTA**
Jan	19.2	16.4	12.9	126	20.3	17.1
Feb	17.8	16.7	19.5	96	18.9	17.1
Mar	16.9	14.5	11.9	104	17.1	14.9
Apr	13.7	11.7	222.9	124	13.8	11.7
May	8.6	8.9	95.6	142	8.4	8.8
Jun	7.9	6.8	137.3	155	7.5	6.7
Jul	7.6	6.1	266.5	177	6.9	5.5
Aug	8.0	6.7	256.8	169	7.4	6.1
Sep	10.2	8.6	75.2	151	10.0	8.2
Oct	11.8	10.7	134.0	163	12.5	10.9
Nov	13.7	12.6	69.8	141	14.8	13.4
Dec	16.1	14.8	139.6	138	17.6	15.8
		Total	**1442**	**1687**		

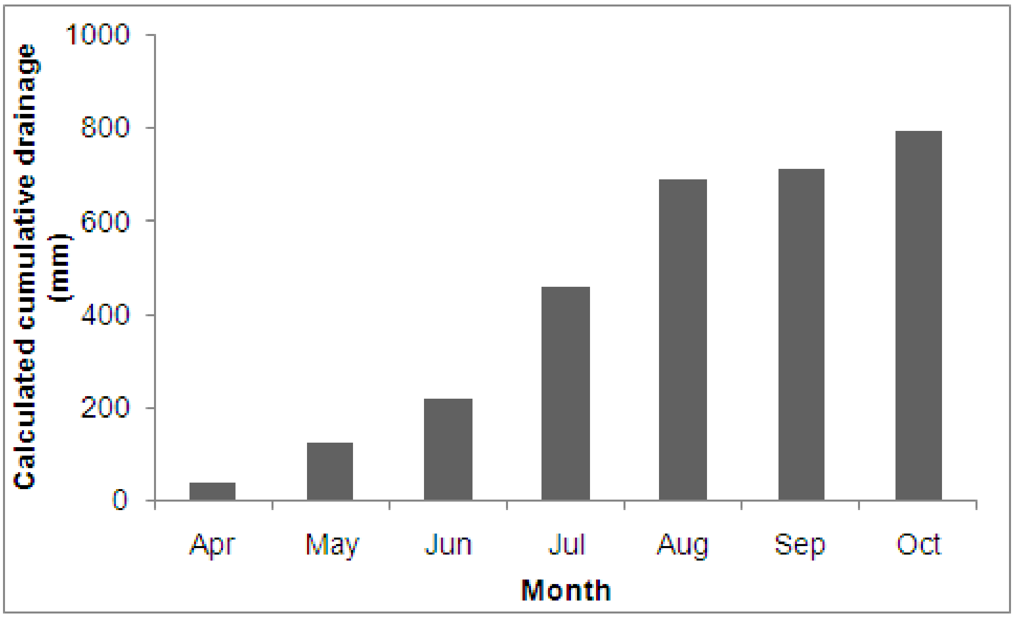

Figure 3: Calculated drainage April-October 2008

5.2 Crop

Due to the drought, the forage crop yield was not as large as target (anticipated yield 12 t DM/ha) and yielded only 6.9 ± 0.9 t DM/ha. Furthermore, the drought meant that silage was used earlier in the season and/or adequate stocks were not built up. This meant a change in how the feeding through winter was managed, compared to the original plan. The initial plan was to feed silage directly on top of the forage crop (which would have meant c. 12-15 t DM/ha) whereas, in practice, the cows were grazed by alternating between the forage crop and the adjacent pasture.

This change has not compromised the experiment in that we were still testing the effects of grazing and the potential benefit of DCD. However, it should be noted that the DM intakes on the grazed areas were less than originally planned and so, therefore, was the amount of N deposited back onto the paddocks by the grazing animals.

5.3 Soil

Topsoil analysis for the experiment sites showed that the soils were adequately supplied with phosphorous, but were low in potassium and sulphur and were marginal for sulphur (Table 2).

The soils had about 6% organic carbon. The C:N ratio ranged between 14 and 16, much wider that the value of around 10 found in many developed pasture soils. This suggests that the soils are still developing after conversion into pastoral agriculture.

Table 2: Soil nutrient status (0-7.5 cm)

Paddock	ID	Org C (%)	Tot N (%)	pH	Ols P (ug/ml)	Ext K (MAF QT)	Ext Mg (MAF QT)	SO_4-S (ppm)
Forage	24H	6.6	0.41	5.8	25	2	7	6
Pasture	24A	6.3	0.44	6.0	29	2	8	5

The amount of mineral N in the soil before grazing reflected the balance between soil (and fertiliser N supply) and crop uptake (Table 3). There was c. 40 kg N/ha in the forage paddock compared with 5 kg N/ha in the pasture field.

This mineral N measured in autumn is an indicator of N leaching risk over the following winter in the absence of further N inputs such as fertiliser or urine. The small amounts of mineral N under pasture suggest effective uptake of any N supplied from the soil (or fertiliser). In contrast, the larger amounts of mineral N under the forage crop suggest an increased leaching risk through the winter.

We can only hypothesise about the source of this N under the forage crop but there are at least two possible reasons:

- Increased release of soil N arising from soil cultivation to establish the crop earlier in the season
- Reduced uptake of soil N and/or fertiliser N because of the summer drought conditions in 2008

Destroying the previous pasture to establish the forage crop will result in mineralisation of the ploughed residues and a large release of mineral N. The amount released will depend on several factors including the previous N inputs to the paddock, but can be >100 kg N/ha (Francis et al., 1992; Shepherd et al., 2001). In a wetter summer, some of this mineralised N would have been susceptible to leaching and it is important to note that, although the focus of this experiment was on the effect of grazing and DCD on nitrate leaching, the indications are that simply growing a forage crop can increase the amount of mineral N in the soils in autumn – and, therefore, increase leaching risk – even without grazing animals.

Therefore, a key part of the management of a forage crop should be to establish it and grow it in such a way as to minimise the amount of soil mineral N remaining in the soil going into winter.

Table 3: Soil mineral N (NH_4-N plus NO_3-N; kg/ha); forage crop and pasture areas before treatments, sampled in June 2008 (SE in parentheses)

Sample area	Sample depth 0-30 cm	30-60 cm	0-60 cm
Forage crop	27 (6.9)	12 (1.8)	39 (8.1)
Pasture	4 (0.2)	1 (2.3)	5 (2.2)

Sampling the soils again in early August, after grazing, gives an indication of the N loading provided to the soil by grazing the forage crop (Table 4). The results from the grazed forage area confirm our hypothesis that grazing the crop deposits large amounts of mineral N (mainly in urine), with 124 kg N/ha measured to 60 cm (as a mean of ± DCD). The majority of this was still held in the top 30 cm (80%), with about 20% in the 30-60 cm layer, i.e. starting to leach to the depth of the porous ceramic cups. We were unable to measure statistically significant effects of DCD on the amount of mineral N at this stage.

We measured only 18 kg N/ha under the ungrazed forage crop (Table 4), indicating that the majority of the 124 kg N/ha measured under the grazed forage crop derived from urine and dung deposition.

Amounts of mineral N under the grazed pasture were again small (with no measurable effect of DCD on the amount of mineral N in the soil) (Table 4), reflecting the smaller amounts of N return and the likely uptake of some of the applied N by the pasture.

Table 4: Soil mineral N (NH_4-N plus NO_3-N; kg/ha), sampled in August 2008

Sample area		Sample depth 0-30 cm	30-60 cm	0-60 cm
Forage crop (grazed)	-DCD	118	21	139
	+DCD	92	16	108
	LSD	113	13	121
	P value	ns	ns	ns
Forage crop (ungrazed)	-DCD only	9	9	18
Pasture (grazed)	-DCD	5	2	7
	+DCD	3	0	3
	LSD	4.5	4.1	5.4
	P value	ns	ns	ns

Table 5 summarises the amount of soil mineral N measured at the end of the experiment in December. There was 39-48 kg N/ha under the grazed forage crop (0-60 cm depth), which compared with 24 kg N/ha in the ungrazed forage crop area and 17-19 kg N/ha under the pasture. These amounts of mineral N at the end of the drainage season reflect the N inputs as urine (plus fertiliser applied in early spring).

Table 5: Soil mineral N (NH_4-N plus NO_3-N; kg/ha), sampled in December 2008

Sample area		Sample depth 0-30 cm	30-60 cm	0-60 cm
Forage crop (grazed)	-DCD	12	28	39
	+DCD	16	32	48
	LSD	3.6	11.3	11.56
	P value	0.02	ns	ns
Forage crop (ungrazed)	-DCD only	5	19	24
Pasture (grazed)	-DCD	14	3	17
	+DCD	13	6	19
	LSD	8.0	12.4	18.7
	P value	ns	ns	ns

5.4 Nitrogen leaching

5.4.1 Forage crop

There was 798 mm drainage between May and October. Nitrate-N losses were large from the grazed forage crop, and were decreased by DCD application. Nitrate-N losses between grazing and soil cultivation were 56 and 44 kg N/ha without and with DCD, respectively (significant at $P<0.05$) (Figure 4). Losses between cultivation and the end of drainage in October were 59 and 43 kg N/ha without and with DCD, respectively (significant at $P<0.05$). Thus, total nitrate-N losses following grazing were 114 and 87 kg N/ha without and with DCD, respectively (significant at $P<0.05$) (Figure 4).

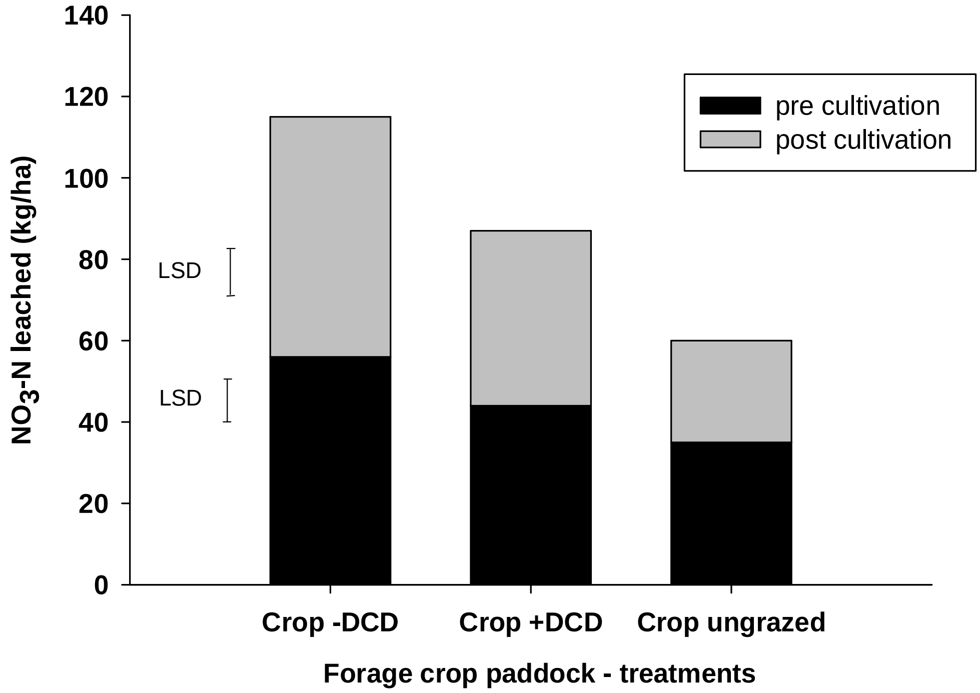

Figure 4: Nitrate-N leached from the forage crop area. Amount leached is split into two periods: before and after cultivation of the soil and drilling of triticale in August. Least Significant Difference (LSD, $P< 0.05$) applies only to ±DCD because the ungrazed crop area was not a part of the replicated field experiment.

Nitrate leaching was also measured in an area of the crop fenced to exclude animals and harvested by hand. Nitrate-N loss over the winter from this ungrazed patch was 60 kg N/ha. Thus, c. 52% of the winter leaching was attributable to growing a forage crop and then leaving the soil bare over winter after its removal; by difference, therefore, about 48% of the N loss could be attributed to excreta/urine deposition.

These preliminary results indicate a high risk of nitrate leaching from winter grazing forage crops in situ, but also a benefit from use of a nitrification inhibitor in this situation.

5.4.2 Pasture

The adjacent grazed paddock similarly showed a highly significant effect of DCD application on nitrate leaching ($P<0.01$); Figure 5. Nitrate leaching losses between May and October decreased from 19 kg N/ha (without DCD) to 6 kg N/ha (with DCD).

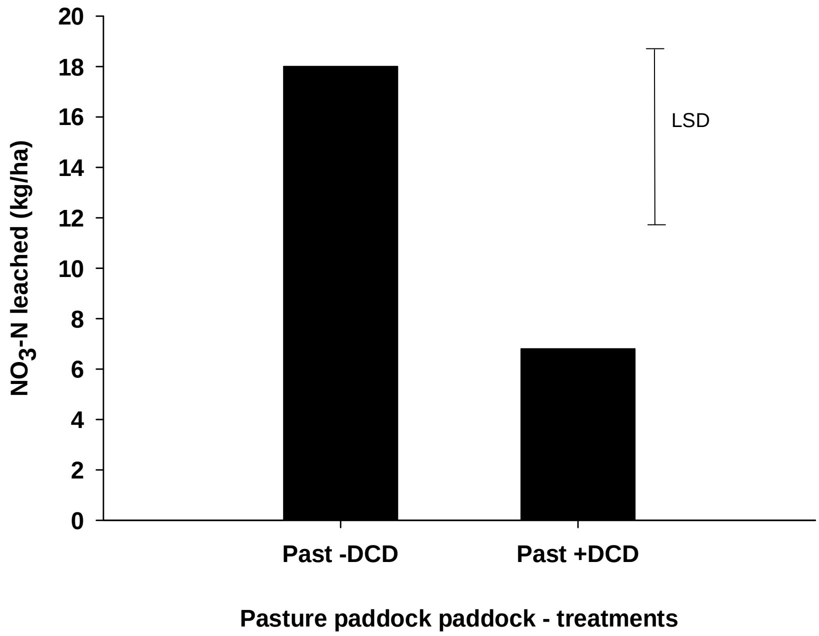

Figure 5: Nitrate-N leached from the pasture paddock. LSD = Least Significant Difference (P<0.05)

Losses were considerably less than from the forage crop, reflecting the differences in soil mineral N measured at the start of autumn and due to:

- Less soil mineral N going into the winter drainage period
- Less N deposited on the pasture than on the forage crop as the animals spent 18 hours of the day on the forage crop and 6 hours on pasture
- Pasture maintained cover over the winter with scope to take up some of the deposited N

Despite these differences in amounts of N leaching between forage and pasture, it is interesting to note that a DCD nitrification inhibitor effect was still measurable.

6. Key messages

We hypothesised that the leaching risk can be high from a forage crop grazed in early winter:

- Large amount of N accumulated in the forage crop before grazing, e.g. a 10 t/ha DM crop could contain 300 kg/ha N
- Grazing of the crop and subsequent urine deposition by the mob, e.g. 80% of the ingested N returned to the soil
- Bare soil thereafter for the remainder of the winter and through early spring until the following crop or reseeded pasture establishes

Measurement of soil mineral N (i.e. the amount of nitrate and ammonium in the soil) and measurement of nitrate leaching under the forage crop demonstrated that this hypothesis is correct.

These are only one year of results and therefore care should be used when interpreting the data. Still, when combined with other experiment data, some key messages are starting to develop.

Grow a good forage crop – Large amounts of N will be released from the soil during cultivation to establish the forage crop in spring, especially if ploughing out pasture. A well grown, high yielding, crop will use this soil N supply; the less nitrate sitting in the soil in autumn, the better in terms of leaching risk. Furthermore, do not over-apply N fertiliser as, again, too much will be a waste and will mean more nitrate is sitting in the soil in autumn waiting to be leached.

Use a nitrification inhibitor – Once the crop has been grazed, the aim should be to stop urine-N converting to mobile nitrate-N that can be leached out of the soil. Results from this one trial plus data from the South Island suggest some promise with this approach.

Delay grazing? – The earlier that urine is deposited on the ground in autumn/winter, the greater the amount of subsequent rainfall and leaching. So delaying grazing should decrease leaching. However, this may not always be practical as the animals will need feeding. One option may be that it might it be possible to prioritise fields based on their soil texture if it varies on a farm, grazing lighter-textured soils later?

Feed the forage crop elsewhere? – This would remove the problem, i.e. stop the urine being deposited on the paddock in winter. In some systems, the forage could be cut and carried to a feedpad, capture the effluent and apply back to paddocks when leaching risk is low. However, this is a higher capital option and won't be appropriate for many farms.

The key message is that there are management options available and research is continuing to explore these. The challenge for farmers will be to take this information and develop it into a viable system. An important point, however, is that managing leaching starts with decision making before the forage crop is sown (how to cultivate, how to fertilise) and not just how the grazing of that crop is managed.

7. Progress against milestones

Milestone	Description	Date	Completed?	On time?
M0	Set up field experiment			
M1	Complete field measurements	1/10/2008	Yes	Yes
M2	Analyse and interpret results	31/12/2008	Yes	Yes
M3	Field meeting held in catchment	28/02/2009	No	No
M4	Complete final report	31/03/2008	Yes	No

The first year field experiment has been successfully completed and reported here. The funding from LTPT allowed useful additional information to be collected that aided interpretation of the core experiment:

- Inclusion of an ungrazed forage crop area demonstrated that a significant proportion of the N leached was derived from growing the crop; we were able to conclude that c. half of the N leaching was due to growing the forage crop and about half was due to grazing activity. This enables us to conclude that good crop management, which minimises the amount of mineral N left in the soil in autumn, is an important step in managing nitrate leaching from a forage crop.
- Inclusion of a DCD (nitrification inhibitor) treatment on the grazed pasture allowed us to demonstrate that this can be an effective method for decreasing nitrate leaching from pasture.

7.1.1 Knowledge transfer activities

A planned activity at the start of the project was to discuss implications of the results in the Taupo catchment.

We will publicly present the results at the end of the second year of field work. This will give more rigor to the information we will be providing. The results will be presented in the wider context of the whole project objectives: “To investigate and develop winter management systems that minimise nitrate leaching from dairy pastures, especially over the winter, providing freedom to operate profitable and sustainable farming systems”.

8. References

Francis, G S, Haynes, R J, Sparling, G P, Ross, D J and Williams, P H (1992). Nitrogen mineralization, nitrate leaching and crop growth following cultivation of a temporary leguminous pasture in autumn and winter. Fertiliser Research 33: 59-70.

Lord, E.I. & Shepherd, M.A. (1993). Developments in use of porous ceramic cups for measuring nitrate leaching. Journal of Soil Science 44, 435-449.

Monaghan, R.M., R.J. Wilcock, et al. (2007). Linkages between land management activities and water quality in an intensively farmed catchment in southern New Zealand. Agriculture, Ecosystems & Environment 118(1-4): 211-222.

Shepherd, M.A., Hatch, D.J., Jarvis, S.C. & Bhogal, A. (2001). Nitrate leaching from reseeded pasture. Soil Use and Management 17, 97-105.

Webster, C.P., Shepherd, M.A., Goulding, K.W.T. & Lord, E.I. (1993). Comparison of methods for measuring the leaching of mineral nitrogen from arable land. Journal of Soil Science 44, 49-62.