EFFECTIVENESS OF *ECO-N* IN REDUCING NITRATE LEACHING LOSSES AT HIGH RATES OF N FERTILISER WITH AND WITHOUT URINE ADDITION

M. Manning[1], K. C. Cameron[2], H. J. Di[2] and A. Robinson[2]

[1]Ravensdown, PO Box 608 Pukekohe, New Zealand
[2] Centre for Soil and Environmental Research
PO Box 85084, Lincoln University, Lincoln 7647, Christchurch, New Zealand
Corresponding author E-mail: keith.cameron@lincoln.ac.nz

Abstract

There is increasing concern that nitrate (NO_3^-) leaching from intensive agriculture can degrade water bodies and potentially threaten human health. Nitrogen (N) inputs from fertilisers, effluents and the urine of grazing animals can cause increased NO_3^- leaching from dairy farm systems. Questions have therefore been asked about the effect of high rates of N fertiliser application on leaching losses from grazed pastures and if these effects can be mitigated by using a nitrification inhibitor. This study used two N fertiliser rates (300 kg N/ha and 500 kg N/ha) with and without urine, and with and without the nitrification inhibitor DCD 'eco-n'. Results show that increasing the fertiliser application rate from 300 kg N/ha to 500 kg N/ha increased the peak concentration of NO_3^- leached from 2.4 NO_3^--N/L to 11.2 NO_3^--N/L. However these values are significantly lower than those from N fertilisers plus urine, where peak the concentration of NO_3^- leached exceeded 220 NO_3^--N/L, 20 times that of fertiliser alone. Similarly, the total amount of NO_3^- leached was highest in the fertiliser plus urine treatments where the amount of NO_3^- leached was on average 45 times the loss from the N fertilisers alone. This confirms that urine addition is the main source of NO_3^- leaching in grazed pastures, even with the high N fertiliser application rates used in this study. The application of eco-n reduced the total NO_3^--N leaching losses by 42% in the fertiliser plus urine treatments. This indicates that eco-n has the potential to significantly reduce the environmental footprint of intensive dairy pastures even at high N fertiliser application rates.

Introduction

Nitrate (NO_3^-) leaching from agriculture is recognised as a threat to surface and ground water bodies quality, and human health (Di & Cameron, 2002b; Monaghan *et al.*, 2007; Goulding *et al.*, 2008; Holland & Doole, 2014). In intensive agriculture there are significant inputs of nutrients in the form of fertilisers, effluents and nutrients returned to the soil through animal excreta, particularly urine (Di & Cameron, 2000; Di & Cameron, 2002b). Urine patches from the grazing animal are concentrated nitrogen (N) hotspots (up to 1000 kg N/ha) and are the main source of NO_3^- leaching in New Zealand pastoral agriculture. Nitrate is leached through the soil when the N applied is greater than the utilisation capacity of the plants and soil microbes, or during high rainfall events where NO_3^- moves quickly through the root zone.

Nitrogen fertiliser is being increasingly used in agriculture, with higher rates being applied to maintain pasture growth and increase milk yield (MacLeod & Moller, 2006). Responses above 10 kg DM/kg N are typical at 200 kg/N/ha fertiliser application rate; with responses of 9 kg DM/kg N having been measured at 400 kg/N/ha (Monaghan *et al.*, 2005) and 8 kg

DM/kg N at 600 kg/N/ha having been measured in mowing trials (Ravensdown Research Report, 2013). This has led to concerns over the effect of higher fertiliser application rates on NO_3^- leaching.

The nitrification inhibitor, dicyandiamide (DCD), previously marketed as 'eco-n' by Ravensdown, has been shown to reduce NO_3^- leaching from grazed pasture systems by up to 60% (Di & Cameron, 2002b; Di & Cameron, 2005). However, its effectiveness in reducing NO_3^- leaching under high N fertiliser application rates and in conjunction with urine deposition has not been tested. Thus the objectives of the study were to determine the effectiveness of eco-n in reducing NO_3^- leaching losses at high rates of fertiliser with and without urine additions.

Methods

Thirty two lysimeters were collected from a Templeton silt loam soil at the Lincoln University Dairy Farm in January 2012. Lysimeters were collected following the method described in Cameron *et al.* (1992). Briefly, this involved placing a metal cylindrical (500 mm diameter x 700 mm depth) casing on the soil surface, digging around the casing ensuring minimal disturbance to the soil structure inside, and gradually pushing the casing down over the soil monolith in small increments. Once the soil had reached the desired depth (700 mm) the soil monolith was cut at the base using a cutting plate, secured on the lysimeter casing and lifted out of the collection site. The gap between the soil core and the metal casing was sealed using petroleum jelly to stop edge flow effects (Cameron *et al.*, 1992). The lysimeters were installed in the lysimeter research facility at Lincoln University.

Two rates of N-fertiliser, with and without eco-n, and; with and without urine were applied to the lysimeters following the application rates described in Table 1. The treatments were randomised and replicated four times.

Table 1: Application rates of fertiliser, eco-N and urine for the treatments.

Treatment	Fertiliser (kg N/ha/y)	Eco-N (kg DCD/ha/y)	Urine (kg N/ha/y)
Control	0	0	0
Fert300	300	0	0
Fert300 + eco-n	300	40	0
Fert500	500	0	0
Fert500 + eco-n	500	40	0
Urine only	0	0	700
Fert300 + Urine	300	0	700
Fert300 + Urine+ eco-n	300	40	700
Fert500 + Urine	500	0	700
Fert500 + Urine+ eco-n	500	40	700

Leachate was collected weekly or when the drainage volume reached 200 mL and analysed for NO_3^- concentration by flow injection analysis (FIA) (FOSS FIA star 5000 triple channel analyser).

Results and Discussion

Nitrate leaching – concentration

When comparing fertiliser application rates, the peak NO_3^- -N concentration in the drainage water was 11.2 mg NO_3^--N/L and 2.4 mg NO_3^--N/L in the Fert500 and Fert300 treatment respectively (Figure 1A). This demonstrates that with increasing application rates, the concentration of NO_3^--N leached rises, a result which is similar to previous studies (Barraclough *et al.*, 1992; Ledgard *et al.*, 1999a). When eco-n was applied the peak NO_3^- -N concentration was reduced by 78% in the Fert500 treatment and by 29% in the Fert300 treatment.

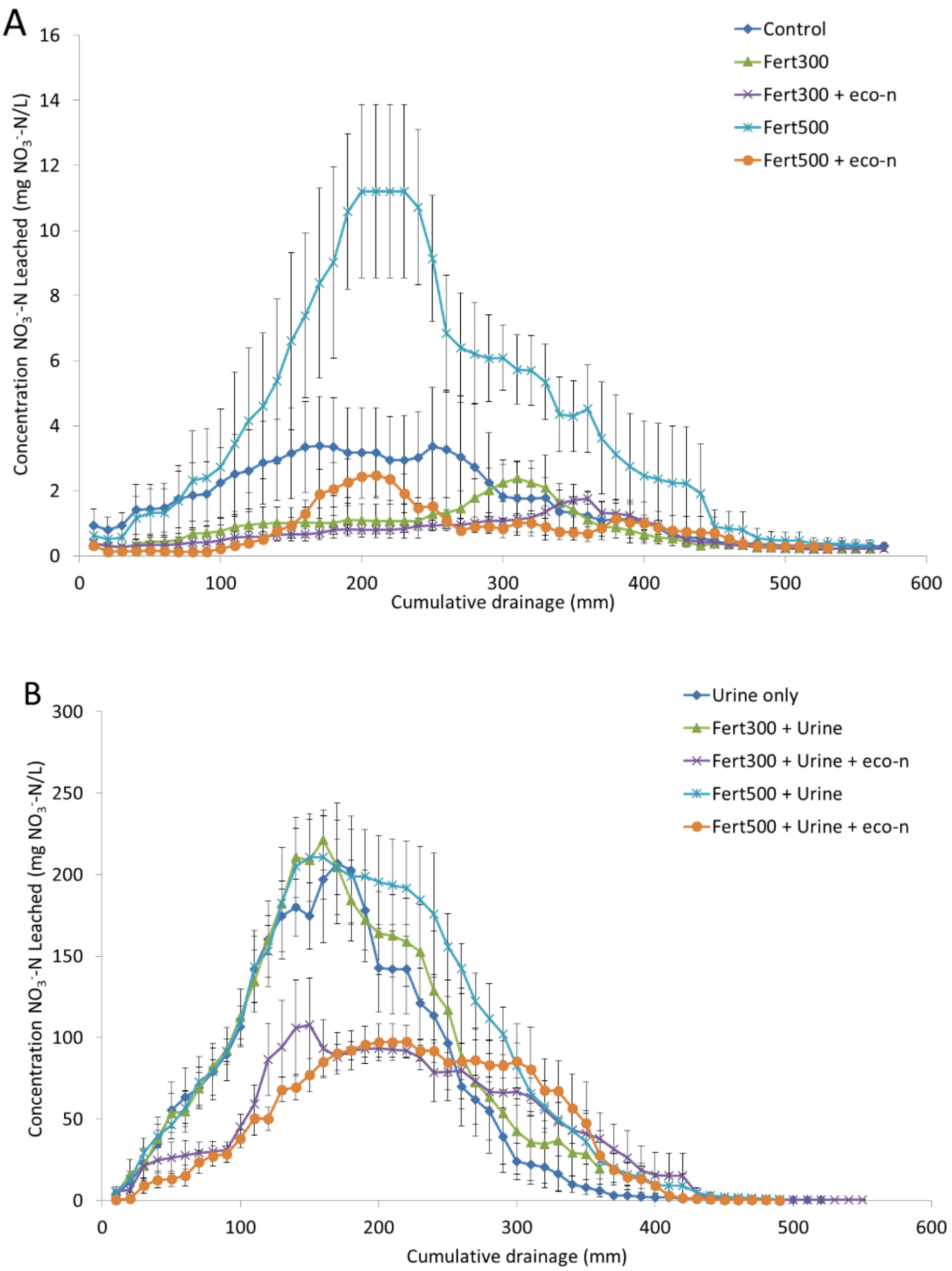

Figure 1: Concentration of nitrate-N leached from lysimeters treated with (A): different rates of fertilisers, with and without eco-n; and (B): different rates of fertiliser and urine, with and without eco-n.

The peak NO_3^--N concentration exceeded 220 mg NO_3^--N/L when urine was applied, with or without N fertiliser (Figure 1B). This was 20 times higher than the fertiliser only treatments. This confirms that urine-N is the main source of nitrate leaching loss (Ledgard *et al.*, 1999b; Di & Cameron, 2002b; Di & Cameron, 2007) on dairy farms even when high rates of N fertiliser are applied. This is caused by the high concentration and amount of N under the urine patch which is far greater than the utilisation capacity of the plants or soil microbes (Di & Cameron, 2002a)

The application of eco-n reduced the peak NO_3^- -N concentration by 51% from 221 mg NO_3^--N/L to 107 mg NO_3^--N/L in the Fert500 + Urine treatment and by 53% from 210 mg NO_3^--N/L to 97 mg NO_3^--N/L in the Fert300 + Urine treatments. This demonstrates the potential of eco-N as a mitigation tool for reducing NO_3^--N leaching from dairy farms using high rates of N fertiliser.

Conclusions

- Increasing fertiliser application from 300 kg N/ha to 500 kg N/ha increases the amount of NO_3^--N leached. However this is insignificant compared to the increase with urine addition.
- Even at the high rates of N fertiliser applied in this study, nitrate leaching loses are still dominantly from urine deposition rather than directly from the fertiliser *per se*.
- Eco-N significantly reduced the total amount of NO_3^--N leached when urine was added in conjunction with the fertilisers.
- Eco-N significantly reduced the amount of NO_3^--N leaching loss by 48% from the Fert500 + Urine + eco-n treatment and 36% from the Fert300 + Urine + eco-n treatment.
- These results confirm that eco-n can reduce NO_3^--N leaching losses even at the high N fertiliser application rates used in this study.

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