The potential role of the nitrification inhibitor DCD for reducing nitrate leaching from grazed grassland

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Introduction

Reducing nitrate leaching from agricultural sources to sensitive receiving waters continues to be a national priority. The latest EPA report states that groundwater and estuarine quality continues to decline with 2% of groundwater supplies exceeding 50 mg L^{-1} NO_3 and 19% of estuaries being classified as eutrophic. The Nitrate Action plan and the Good Agricultural Practice for Protection of Waters Regulations 2006 (SI 378 of 2006) have led to the introduction of compulsory measures for farmers to improve nitrogen utilisation efficiency and control losses to water. Nitrification inhibitors have been shown to increase nitrogen utilisation by plants through slowing down the rate at which ammonium is converted to nitrate. Nitrification inhibition also has the environmental benefits of reducing nitrate leaching and nitrous oxide emissions from soils (e.g. Di and Cameron, 2004). The objective of this lysimeter experiment was to assess the effect of DCD (dicyandiamide), a commercially used nitrification inhibitor, on nitrate leaching from Irish grassland soils after urine and fertiliser applications.

Materials and Methods

Lysimeters (0.8 m diameter x 1 m deep) with three different soils [Clonakilty (sandy loam), Elton (loam) and Rathangan (clay loam)], were sampled following the procedure given in Cameron et al. (1992) and installed at the lysimeter facility at Johnstown Castle. Seven treatments were applied in November 2006: 1. Control; 2. Low Fertiliser (FL) [141 kg N ha^{-1}]; 3. High Fertiliser (FH) [291 kg N ha^{-1}]; 4. Urine (U) [3 L of fresh cow urine, 5.1 g N L^{-1}, ~306 kg N ha^{-1}] + FL (U FL); 5. U+FH (U FH); 6. U+FL+DCD (U FL DCD); and 7. U+FH+DCD (U FH DCD). Nitrogen fertiliser was applied as CAN and urea in 5 (FL) or 7 (FH) applications through the growing season. DCD was applied in November 2006 and March 2007 at a rate of 10 kg ha^{-1} in 1000 L water ha^{-1}. Urine was collected in the milking parlour and landspread in November 2007. Drainage water was collected, quantified and subsampled for NO_3-N determination using standard colorimetric methods. Data were analysed by GLM and contrast estimates using SAS.

Results and Discussion

Nitrate loads were significantly higher in the drainage water from the lighter Clonakilty and Elton soils than from the Rathangan soil ($P<0.001$). A significant treatment effect ($P<0.0001$) was also observed with all urine treatments showing higher NO_3-N losses than the control, FL and FH treatments. Over the three soil types NO_3-N loads were significantly ($P<0.01$) lower from DCD treatments than from non-DCD treatments.

The concentration of NO_3-N in drainage water was below 10 mg L^{-1} (Fig. 1) from all soil types for the non-urine treatments (control, FL, FH). Following urine application, however, NO_3-N concentrations gradually increased with increasing cumulative drainage. On the Elton and Clonakilty soils, maximum drainage NO_3-N concentrations were observed after 200-300 mm drainage. The poorly drained Rathangan soil had significantly lower NO_3-N losses and this reduction in leaching may be attributed to the higher denitrification potential in this soil type. On the freely drained Clonakilty soil the maximum drainage NO_3-N concentration was approximately 50% lower from DCD compared to non-DCD treatments (60 mg L^{-1} compared to ~118 mg L^{-1}).

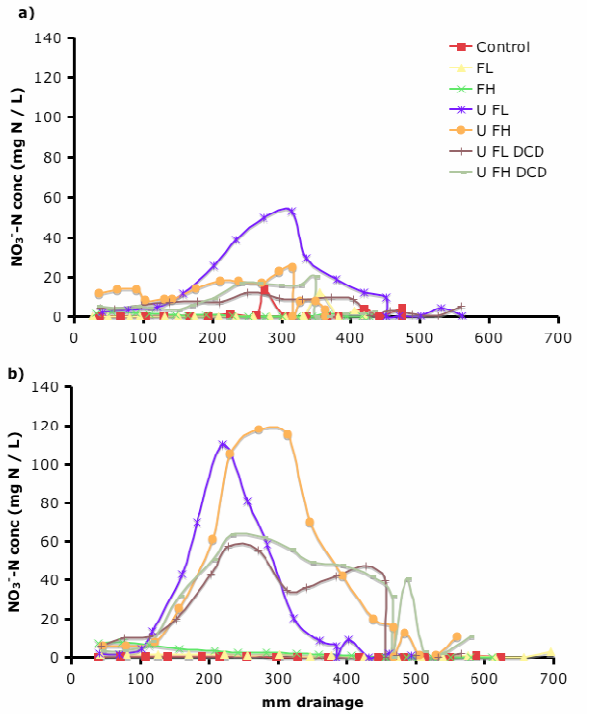

Fig 1. Temporal variation of lysimeter drainage NO_3-N concentration (mg L^{-1}) from (a) Rathangan, (b) Clonakilty soils.

Conclusions

Nitrate leaching was significantly affected by soil type and treatment. Poorly drained soils had lower NO_3-N leaching than freely drained soils. DCD significantly reduced NO_3-N load and the peak NO_3-N concentrations in drainage, particularly on the free draining soil. The effect of DCD looks promising for reducing nitrate leaching from free draining grazed grassland but further research is required on its practical use.

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References

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