Urinary recovery of dicyandiamide (DCD) pulse-dosed into the rumen of non-lactating dairy cows, and the effects of applying urine with DCD to lysimeters on nitrous oxide and nitrate leaching in Ireland

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Introduction

Urine excreted by dairy cows is a source of nitrogen (N) to the sward. The N content of urine is high, up to 1000 kg N/ha and is usually in excess of sward requirements. Surplus N is usually lost through a number of pathways including nitrate (NO_3^-) leaching and nitrous oxide (N_2O) emissions. Dicyandiamide (DCD), a nitrification inhibitor, has been shown to reduce NO_3^- leaching and N_2O emissions when applied as a fine particle suspension (FPS) to grazed paddocks. The objectives of the study were to: (1) quantify the recovery of DCD in the urine when DCD was pulse-dosed DCD into the rumen of non-lactating dairy cows; and (2) to examine the effects of urine collected from dairy cows pulse-dosed with DCD on N_2O emissions and NO_3^- leaching using lysimeters.

Materials and Methods

Eight non-lactating Holstein Friesian dairy cows fitted with rumen cannulae were used in a latin square design. The experiment had two 12-day periods consisting of a 6-day acclimatization stage and a 6-day treatment stage, separated by a 10-day rest period. Treatments were: (1) Control (CON) - 500 ml distilled water daily; and (2) DCD - 0.1 g DCD/kg liveweight (LW) dissolved in 500 ml distilled water daily. Treatments were pulse-dosed into the rumen. Animals were housed in individual stalls to allow for urine collection and were offered fresh perennial ryegrass daily at 2.5 times maintenance. The collected urine was weighed and sampled daily at 08:00 hrs, and stored at -20°C until analysis. The DCD concentration in the urine samples was determined using a high performance liquid chromatograph (HPLC) method (O'Connor *et al.* 2013).

Urine from both cow treatments plus a control treatment (distilled water) was applied to lysimeters (30 cm diameter; 70 cm depth) on 12 October 2010. There were two soil types (free draining and poorly draining) and four replicates per treatment. Urine only, urine + DCD or distilled water was applied to each lysimeter at a rate of 0.48 l, equivalent to a urination volume of 2.2 l (Williams and Haynes, 1994) and a urine patch size of 0.32 m^2 (Moir *et al.* 2011). Leachate samples were collected on a number of occasions from each lysimeter until day 172 post treatment application and NO_3^- concentration determined. The N_2O fluxes were measured on 23 occasions (up to day 126) following treatment application using a closed chamber technique (Smith *et al.* 1995). Gas samples were analysed using a gas chromatograph (GC) fitted with an electron capture detector and automatic sampler. The N_2O flux was calculated based using the equation described by (Li and Wang 2007)

Urine DCD concentration, the recovery of DCD in urine, N_2O and DCD leachate concentrations and N_2O flux were analysed using linear mixed models that allowed for repeated measurements using the MIXED procedure in SAS (SAS 2003). An ANOVA was performed on total NO_3^- leached, total N_2O emissions and total DCD leached using the GLM procedure in SAS (SAS 2003).

Results

The N loading rate of urine + DCD was 508 kg N/ha and of urine only was 451 kg N/ha. The concentration of DCD in the urine + DCD treatment was 77 kg DCD/ ha. The average recovery of DCD pulse-dosed into the rumen of cows was 82.3% (Fig. 1) and no DCD was detected in

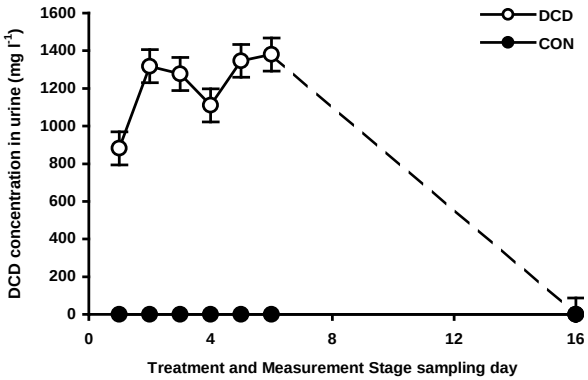

Figure 1. The effect of pulse-dosing DCD into the rumen of grass-fed non-lactating dairy cows over a 6-day treatment stage, and 10 days after ceasing the dosing, compared to pulse-dosing a control (CON) treatment of distilled water, on urinary DCD concentration (mg/L).

Table 2. The effect of control, urine only and urine + DCD treatments applied to lysimeters on total NO_3^- (kg NO_3^--N/ha) leached and total N_2O (kg N_2O-N/ha) emissions and the control losses from the free draining and poorly draining soils (*, $P<0.05$; **, $P<0.01$)

Treatment (Total N applied)	Free draining	Poor draining	Free draining	Poor draining
	kg NO_3—N/ha		kg N_2O-N/ha	
Control (0 kg N/ha)	1.5	1.7	1.5	1.5
Urine (451 kg N/ha)	100	81.1	13.6	12.1
Urine + DCD (508 kg N/ha)	9.0	11.6	2.2	5.2
s.e.m.	19.27	24.61	2.32	2.32
Significance (Treatment)	**	*	**	**

samples 10 days after the cessation of dosing. There were no deleterious effects of DCD on any of the animal rumen function parameters or blood parameters measured. The urine from cows pulse-dosed with DCD reduced N_2O emissions and NO_3^- leaching by 57-84% and 86-91%, respectively, depending on soil type (Table 1).

Conclusions

Dosing DCD to cows can be provide an application method of applying DCD directly to grasslands, and therefore potentially provide a mitigation strategy to reduce the environmental emissions from grass based systems. Further research is required on a suitable administration method, and potential transfer to milk in lactating cows.

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References

O'Connor PJ, Hennessy D, Lynch MB, Slattery H, Lewis E (2013) The effect of pulse-dosing non-lactating dairy cows with the nitrification inhibitor dicyandiamide (DCD): the recovery of DCD and DCD effects on blood metabolites, rumen function and diet digestibility. *Livestock Science* **155**, 30 – 37.

Williams PH, Haynes RJ (1994) Comparison of initial wetting pattern, nutrient concentrations in soil solution and the fate of15N-labelled urine in sheep and cattle urine patch areas of pasture soil. *Plant Soil* **162**, 49-59.

Li D, Wang X (2007) Nitric oxide emission from a typical vegetable field in the Pearl River Delta, China. *Atmospheric Environment* **41**, 9498–9505.

Moir JL, Cameron KC, Di HJ, Fertsak U (2011) The spatial coverage of dairy cattle urine patches in an intensively grazed pasture system. *Journal of Agricultural Science* **149**, 473-485.

SAS (2003) Statistical Analysis System user's guide, Version 9.1.3, Cary, NC: SAS Institute Inc.

Smith KA, Clayton H, McTaggart IP, Thomson PE, Arah JRM, Scott A (1995). The measurement of nitrous oxide emissions from soil using chambers. *Philosophical Transactions of the Royal Society*, London. **351**, 327–338.