

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

Patrick J O'Connor^A, Eva. Lewis^A, Helen Slattery^B and Deirdre Hennessy^A

^A Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland

^B Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork, Ireland

Contact email: Deirdre.hennessy@teagasc.ie

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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 (NO₃⁻) leaching and nitrous oxide (N₂O) emissions. Dicyandiamide (DCD), a nitrification inhibitor, has been shown to reduce NO₃⁻ leaching and N₂O 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 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 N₂O emissions and NO₃⁻ 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 m² (Moir *et al.* 2011). Leachate samples were collected on a number

of occasions from each lysimeter until day 172 post treatment application and NO₃⁻ concentration determined. The N₂O 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 N₂O flux was calculated based using the equation described by (Li and Wang 2007)

Urine DCD concentration, the recovery of DCD in urine, N₂O and DCD leachate concentrations and N₂O 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 NO₃⁻ leached, total N₂O 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

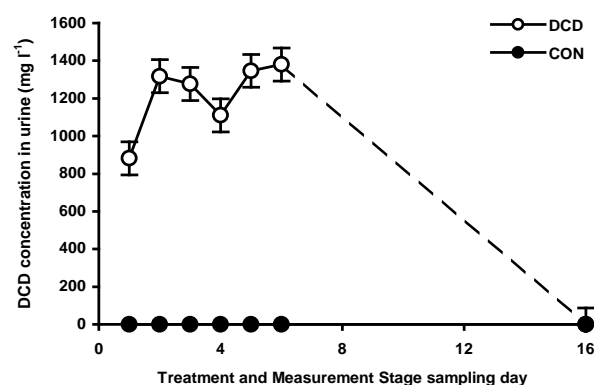


Figure 1. The effect of pulse-dosing DCD into the rumen of grass-fed non-lactating dairy cows over a 6-day treatment stage, and 10 days after ceasing the dosing, compared to pulse-dosing a control (CON) treatment of distilled water, on urinary DCD concentration (mg/L).

Table 2. The effect of control, urine only and urine + DCD treatments applied to lysimeters on total NO₃⁻ (kg NO₃⁻-N/ha) leached and total N₂O (kg N₂O-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 ₂ O-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 N₂O emissions and NO₃⁻ 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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