ASSESSING THE EFFECT OF SPREADING METHOD AND USE OF THE NITRIFICATION INHIBITOR DCD, ON TRACE GAS EMISSIONS FROM GRASSLAND AMENDED WITH CATTLE SLURRY

Cahalan E.[*1,2], Müller C[2], Richards K. G.[1], Ernfors M.[1], Khalil M. I.[1], Watson C. J.[3], Laughlin R. J.[3], Hennessy D.[4], Devaney D.[1]

[1]Teagasc, Johnstown Castle Environmental Research Centre, Co. Wexford, Ireland.
[2]School of Biology and Environmental Science, University College Dublin, Belfield, Dublin 4, Ireland.
[3]Agri-Food and Biosciences Institute, Newforge Lane, Belfast, BT9 5PX, Northern Ireland.
[4]Teagasc, Moorepark Dairy Production Research Centre, Fermoy, Co. Cork, Ireland.
[*] Tel +353 53 9171200. enda.cahalan@teagasc.ie

1 INTRODUCTION

The spreading of cattle slurry to grassland can contribute to GHG emissions from the soil (Rodhe, *et al.,* 2006). Cattle slurry when applied to grassland can have variable results on herbage production and GHG emissions; this is mainly due to timing of application (Laws *et al.,* 2002) and variation of the slurry nutrient content (O'Bric, 1991). Applying slurry in optimum weather conditions and with a nitrification inhibitor could reduce nitrogen loss to the environment

Extensive research has been carried out in New Zealand in recent years to address the problem of nitrogen losses from grassland through nitrate leaching and denitrification, by using the nitrification inhibitor dicyandiamide (DCD) (Di & Cameron, 2004). This inhibitor is applied to the pasture as a fine particle suspension and acts as a barrier between dung and urine deposited by grazing animals and the soil (Di & Cameron, 2005).The formulated spray marketed as "eco-n™" is applied at a rate of 10 kg DCD ha^{-1} and has been shown to reduce nitrate leaching by up to 76% (Di & Cameron, 2004).

These environmental benefits would greatly benefit agricultural systems in Ireland and other countries with high annual rainfall levels. In Europe the Nitrates Directive (91/676/EEC) (Anon, 1991) was introduced to ensure water quality is kept at a high standard using measures to reduce nitrogen contamination of surface and groundwater. In Ireland cattle are generally housed in slatted units over the winter period, to facilitate nutrient management when ground conditions are poor and nitrogen losses through leaching and surface run-off are likely to occur. Slurry storage facilities were recently upgraded and capacity was increased in Ireland in 2006 under the Farm Waste Management Scheme (European Council, 1999). Large volumes of slurry nutrients are therefore accumulated over the storage period and need to be applied in order to reduce fertiliser N usage.

The objective of this experiment was to evaluate the potential role of the nitrification inhibitor DCD in reducing GHG emissions from cattle slurry applied to grassland. Our method will include one operation of agitating the DCD into slurry before landspreading saving the need to spray the pasture beforehand which could reduce expenses and soil compaction. The incorporation of DCD in slurry would ensure DCD is placed where nutrients are being applied. We also are investigating the effect that slurry spreading method (Bandspread and splashplate) has on DCD amended cattle slurry in reducing GHG emissions.

2 MATERIALS AND METHODS

2.1 Experimental Design

A randomised block design was laid out on a grassland field site at Johnstown Castle Research Centre, Co. Wexford, Ireland (52°18'; 6° 30'W). The soil texture was a fine loam soil with imperfect drainage. There were five treatments used: (1) Cattle Slurry (CS) Bandspread (BS) application method with (+) DCD; (2) CS BS without (-) DCD; (3) Cattle Slurry (CS) Splashplate (SP) application method (+) DCD; (4) CS SP (-) DCD; (5) control treatment. The control plots received a water equivalent the same as the slurry plots. Cattle slurry was applied at a rate of $33 m^3\ ha^{-1}$, which is the same agronomic rate used for 1st cut silage production in Ireland. The slurry was applied manually using 10 l watering cans. For the bandspread treatment lines were spaced 20 cm apart. For the splashplate treatments an attachment was fitted to the nozzle of the watering can, to simulate the same coverage typical of a conventional splashplate slurry tanker. The plot size used was 3 x 2 m and each treatment was replicated six times. There were three application dates in the year (March, June & October) and the experiment is being run over 2 years (started October 2008). The application dates used are similar to those practised on Irish grassland farms throughout the growing season.

2.2 Trace Gas Measurements

Gaseous emissions of both nitrous oxide and methane were measured from the plots using the static chamber method (Hutchinson & Mosier, 1981). The stainless steel chambers were 40 cm x 40 cm wide and 10 cm high. Collars were inserted into the plots to 15 cm deep, in the centre of each plot. The collars had a water trough for the chamber to fit into and were filled with water to prevent gas exchange with the external atmosphere. The placement time for the chambers was 25 mins. The headspace in each chamber was sampled at both t0 and t25. Samples were taken from the septa on the top of the chambers using a 20 ml polypropylene syringe. The plunger was pushed up and down three times to ensure thorough mixing of the headspace and the samples were injected into 7 ml, pre-evacuated glass vials which were stored before analysis by the Varian 3800 gas chromatograph. Sampling of the plots occurred frequently after slurry was applied until background emission levels were common amongst all treatments. Samples were taken on days 0, 1, 2, 3, 4, 5, 6, 7, 9, 11, 14, 17, 20, 24, 28, 35, 42, 56 following slurry application. This varied slightly over the three application dates but was kept as standardised as possible. The flux was calculated as the difference in the headspace concentrations at t25 and t0 and the flux results are expressed as grams of N_2O-N ha^{-1} d^{-1}.

TABLE 1 **Meteorological Data (from slurry application until end of sampling)**

	March 2009	**June 2009**	**October 2009**
Application date	09/03/2009	24/06/2009	12/10/2009
Total precipitation (mm)	55.6	181	240
Average Soil Temp (°C at grass level)	7.5	18.5	10.7
Solar radiation (J cm^{-2}, 3 day avg. post app.)	718	1901	700

2.3 Statistical Analysis

After the cumulative fluxes were obtained for each plot a two factor ANOVA test was used to check for statistical differences between treatments using SPSS Statistics version 17.0. A confidence level of 0.05 was regarded as statistically significant.

3 RESULTS AND DISCUSSION

The cumulative nitrous oxide results for both the bandspread and splashplate emissions in March can be seen in (Figure 1). Bandspread applied slurry amended with DCD reduced nitrous oxide emissions by 51%, although this was not found to be significant ($p>0.05$). The splashplate applied cattle slurry with DCD reduced nitrous oxide emissions by 50%; this was also not a significant reduction. For the summer slurry application bandspread DCD amended slurry emitted 29% less nitrous oxide than the splashplate slurry containing DCD. Slurry without DCD emitted 47% less nitrous oxide when bandspread compared to applying with the splashplate. Emissions were lower than in March, this could be due to ammonia volatilisation reducing available nitrate in the soil. There was no significant DCD effect at this application timing either. The October application was applied on (12/10/2009). There was a significant effect ($p<0.05$) of DCD for both application methods. Bandspread slurry amended with DCD reduced the emissions by 282 % compared to the bandspread without DCD treatment. Splashplate slurry amended with DCD reduced nitrous oxide emissions by 172 % compared the splashplate slurry without DCD. Bandspread slurry without DCD emitted 63 % more nitrous oxide than the splashplate treatment without DCD. This could possibly be due to the higher anaerobic conditions created under the bands of slurry. The coefficient of variation for bandspread slurry was 191, 102, 132 % in March, June and October respectively, over the same period for bandspread the CV % was 123, 99 and 142 respectively. This large variation has led to non-significant differences between the treatments. A high coefficient of variation is common when measuring N_2O fluxes from grassland using static chambers (Velthof and Oenema, 1993). October applied slurry had a high CV % but due to the magnitude of the reduction in emissions in the DCD treatments there was a significant treatment effect. In order to reduce this variation we propose to apply macerated slurry separately to the 0.16 m^2 chamber area not just to the whole 6 m^2 plot area. This should reduce the spatial variation within the chamber area. The emission factors over the sampling period were consistently lower than the 1 % manure emission factor set by the Intergovernmental Panel on Climate Change (IPCC, 2006). The emission factors in October were 0.14 % for DCD amended slurry and 0.31 % for slurry without DCD. Both figures are well below the default value set by the IPCC.

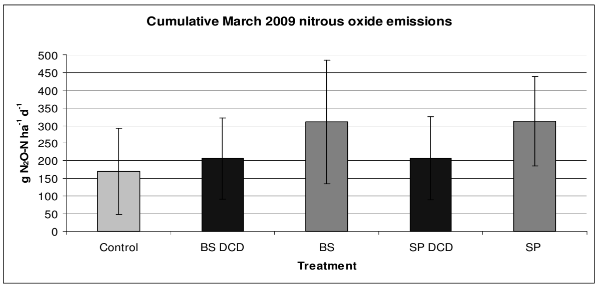

FIGURE 1 **Cumulative N_2O-N emissions after application of cattle slurry in March**

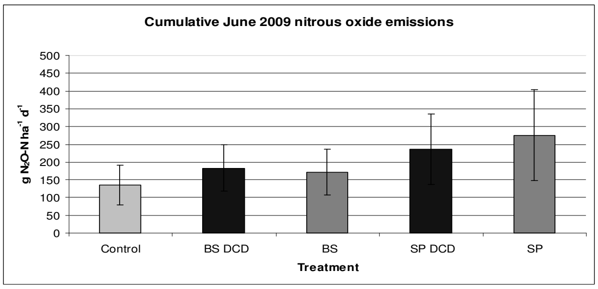

FIGURE 2 **Cumulative N_2O-N emissions after application of cattle slurry in June**

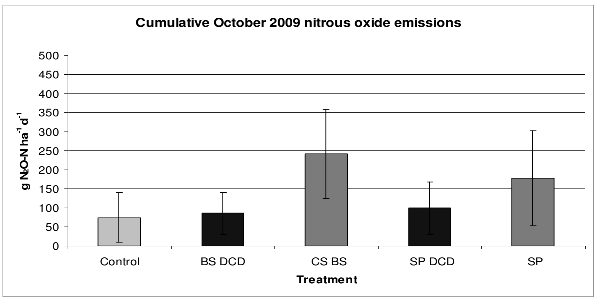

FIGURE 3 **Cumulative N_2O-N emissions after application of cattle slurry in October**

4 CONCLUSIONS

March and June slurry applications of DCD amended cattle slurry did not show a significant reduction in nitrous oxide emissions irrespective of application method. Large within treatment variation could be the reason for this in both cases but in June high soil temperatures and ammonia volatilisation could reduce the potential for denitrification. The DCD amended slurry when applied in October did show a significant reduction in nitrous oxide emissions for both spreading methods.

ACKNOWLEDGEMENTS

This research is financially supported under the National Development Plan, through the Research Stimulus Fund, administered by the Department of Agriculture and Food.

REFERENCES

Anon 1991. Directive of the Council of December 12 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC). European Commission, Brussels, p 8

Di H J, Cameron K C 2004. Treating grazed pasture soil with a nitrification inhibitor, eco-n TM, to decrease nitrate leaching in a deep sandy soil under spray irrigation—a lysimeter study. *New Zealand Journal of Agricultural Research,* 47**,** 351-361.

Di H J, Cameron K C 2005. Reducing environmental impacts of agriculture by using a fine particle suspension nitrification inhibitor to decrease nitrate leaching from grazed pastures. *Agriculture, Ecosystems & Environment.*

European Council 1999. Council Regulation (EC), 1257/1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund and amending and repealing certain regulations*. Official Journal of the European Union* L 160 80–102.

Hutchinson G L, Mosier A R 1981. Improved Soil Cover Method for Field Measurement of Nitrous Oxide Fluxes. Soil Science Society of America Journal, 45**,** 311-316.

IPCC: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, prepared by the National

Greenhouse Gas Inventories Programme, edited by: Eggleston H S, Buendia L, Miwa K., Ngara T, Tanabe K 2006. *N2O emissions from managed soils, and CO2 emissions from lime and urea application*, Volume 4, Chapter 11, IGES, Hayama, Japan,

Laws J A, Smith K A, Jackson D R, Pain B F 2002. Effects of slurry application method and timing on grass silage quality. *The Journal of Agricultural Science,* 139**,** 371-384.

O' Bric C 1991. A survey of the nutrient composition of cattle and pig slurries. M.Agr.Sc Thesis, University

College Dublin.

Rodhe L, Pell M, Yamulki S 2006. Nitrous oxide, methane and ammonia emissions following slurry spreading on grassland. *Soil Use and Management,* 22**,** 229-237.

Velthof G L, Oenema O 1993. Nitrous oxide flux from nitric-acid treated cattle slurry applied to grassland under semi-controlled conditions. *Netherlands Journal of Agricultural Science*, 41: 63-80.