AHDB Dairy Grasslands, Forage and Soils Research Partnership

Soil compaction and greenhouse gas emissions

Report prepared for AHDB Dairy

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Executive Summary

Background and Objectives: Nitrous oxide (N_2O) has been recognised as a major contributor to anthropogenic warming as a greenhouse gas. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report estimated the global warming potential of N_2O to be 300 times that of Carbon Dioxide (CO_2). It has been calculated that approximately 7% of the UK greenhouse gas emissions are from agriculture, with 3.5% of this figure being from N_2O, mostly from soil microbial activity in agricultural soils as a consequence of organic and inorganic fertiliser use. Grasslands are the most important source of N_2O in UK agriculture and account for approximately 28.6% of the total UK emissions. The N_2O emissions from grassland tend to be associated with the addition of fertilisers and occur in short bursts or fluxes after application. Production of N_2O fluxes from the soil are dependent on a number of factors; both physical and biological. However, N_2O from soils is produced largely by the microbial process of denitrification and to a lesser extent by nitrification. The physical variables that can potentially increase the positive fluxes of N_2O are enhanced by the compaction of the soil as this reduces the air filled pore spaces for nitrification and increases the water filled pore spaces where denitrification activity is more likely to occur. Previous studies have shown that the application of a nitrification inhibitor, dicyandiamide (DCD), can reduce the emissions of N_2O. DCD is water soluble and so has the advantage that it can be applied in liquid form and inhibits the initial nitrification stage. The objectives of the study were to: a) investigate the affect of soil compaction on levels of N_2O emissions b) assess the use of a nitrification inhibitor (DCD) on the reduction of N_2O emissions c) assess soil alleviation effects on N_2O emissions **Technical approach:** To investigate the effect of soil compaction from trampling by cows and vehicle compaction (a weighed tractor) on grassland soil structure and N_2O emissions compared to those from an area of minimised compaction. Comparisons of any potential effects were made at two different sites; SRUC and HAU. These sites were chosen for contrasting soil type (heavy, poorly draining, silty clay loam at SRUC and light, sandy, freely draining at HAU) and weather (wetter cooler at SRUC and drier warmer at HAU). Each year for three years from 2012 to 2014, the grass was cut for silage three times a year and the N_2O emissions compared for any effect from the soil compaction. Any changes to the soil structure were monitored through measurements of bulk density along with visual assessments using the Visual Evaluation of Soil Structure (VESS). The effect of alleviation of the compacted soil through the use of surface aeration (spiking) or sward lifting on the N_2O emissions were monitored. Fertiliser was applied three times during each year of the experiment; once as an inorganic fertiliser (Urea at 60 kg N ha) in the middle of March, with slurry applied using a trailing shoe (30m^3/ha) within two weeks of the first (end of May) and second (mid July) grass silage cuts. A nitrification inhibitor, with the active ingredient dicyandiamide (DCD), was applied within one hour of each fertiliser treatment. The nitrification inhibitor was applied as a 2% solution, to give an application rate equivalent of 10 kg/ha, during the first two years of the experiment. Gas fluxes (N_2O) were measured using two closed chamber systems on each treatment area, these were 0.2 m tall polypropylene cylinders of diameter 0.4 m and were pushed into the soil to a depth of up to 5 cm to provide a head space of approximately 0.02 m^3 on enclosure with an aluminium lid. The chambers were sampled on a fortnightly basis through the late winter, increasing to weekly sampling in the spring and then twice weekly once the fertiliser treatments

were applied and continued until the late summer after the third grass cut when the sampling returned to weekly for October and stopped during November and December.

Key results: There were significantly enhanced emissions of mean N_2O from soil compaction treatments by 29% for the trampling and 60% for the tractor compactions at SRUC and 15% for the trampling and 16% for the tractor compaction at HAU over the three years of the experiment.
The use of the DCD significantly reduced N2O emissions ($P<0.01$) for all plots at SRUC and HAU by 23.2% and 47.6%, respectively over the course of the experiment.

Table 5.2.1. Accumulated N_2O emissions from compaction treatments with and without a nitrification inhibitor (DCD) at SRUC and HAU.

Treatment	Accumulated N_2O emissions (g N_2O-N /ha)		Reduction (%) between DCD addition and no DCD
	2012-13	2012-14	2012-13
SRUC			
Trampled	2509	4929	26.4 (***)
Trampled + DCD	1846		
Tractor	3312	5930	38.2 (***)
Tractor + DCD	2046		
No Compaction	2203	4108	23.2 (**)
No Compaction + DCD	1692		
HAU			
Trampled	2801	3495	47.6 (***)
Trampled + DCD	1468		
Tractor	3291	4085	46.4 (***)
Tractor + DCD	1765		
No Compaction	2718	3436	44.9 (***)
No Compaction + DCD	1497		

Sward lifting increased the emission of N_2O for approximately 8 weeks after implementation, especially for the more compacted soils. The use of a soil slitter also increased N_2O emissions for a similar length of time in the compacted soils.

Farmer messages: The main messages were:

- Compaction increased emissions of N_2O from agricultural grassland
- Increased emissions of N_2O were not consistent for the two soil types, as the heavier soil produced greater levels than the lighter soil.
- The use of a nitrification inhibitor (DCD) only accounted for a saving of up to 1.5 kg N ha and would be cost neutral at best, however it did significantly reduce N_2O emissions.
- Soil alleviation can result in an initial increased emission of N_2O especially if the soil does not have a problem with compaction. This has implications for controlling greenhouse gases, in that improving soil structure could encourage a greater release of N_2O.

Further exploitation: This work has been presented at research conferences and should help in the refining of the UK's GHG emissions factors. The use of DCD was shown to be important in controlling GHG emissions but was not a cost advantage in retaining N fertiliser and supported previous work undertaken by Defra.

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