The effect of urea fertiliser formulations on gross nitrogen transformations in a permanent grassland soil.

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1. Objective:

To evaluate the effect of the of the urease inhibitor N-(n-butyl) thiophosphoric triamide (n-BTPT) and/or a nitrification inhibitor dicyandiamide (DCD) on gross nitrogen (N) transformations in a permanent grassland soil.

2. Introduction:

Increased food production is needed to feed an expanding population (FAO, 2014). Increased production must be achieved in the context of pressures to reduce GHG emissions. Initial results from a related study (Harty, 2015 unpublished data) shows that switching N fertiliser from calcium ammonium nitrate (CAN) to specific urea based formulations significantly reduced both direct and indirect N_2O emissions without affecting grassland yields. This study examined the effect of a number of urea based fertiliser formulations on gross N transformations in a permanent pasture soil under laboratory conditions at Hillsborough, Co. Down, Northern Ireland.

Methods:

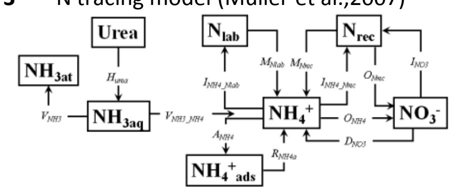
- Soil lab incubation study conducted at constant 15°C and 65% WFPS
- Liquid urea based fertiliser treatments labelled with ^{15}N to 60 atom %
  - Urea
  - Urea + n-BTPT
  - Urea + DCD
  - Urea + n-BTPT + DCD
- Fertiliser treatments were applied to soil jars (4 replicates)
- Each set of jars was destructively extracted using KCl
  - At 8 sampling times, over 25 days
  - Mineral N concentration determined.
- KCl extract used to determine ^{15}N enrichment of NO_3^- (**Fig 1**) and NH_4^+ (**Figs 2a and b**) by conversion to N_2O (Stevens and Laughlin 1994; Laughlin et al 1997) using isotope ratio mass spectrometry (IRMS).
- Modelled output determined by simultaneously adjusting parameters for N pools, N transformations and kinetic settings until the model output best fitted the measured concentration and enrichment values (**Fig 3**). Model best fit determined using the Akaike information criterion.

Fig 1–NO3 conversion

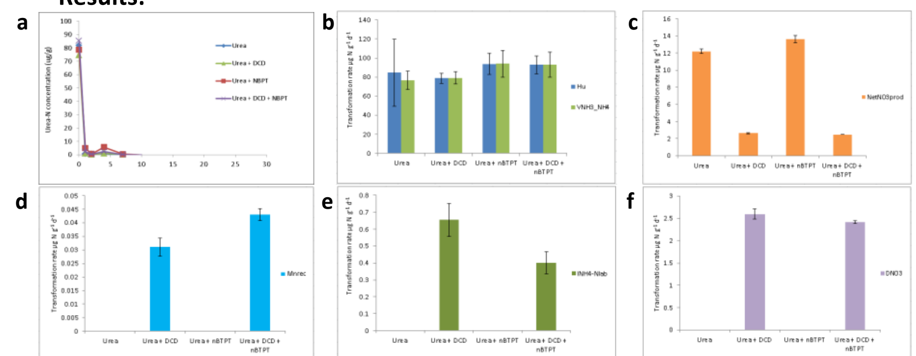
Fig 2a–NH_4 conversion

Fig 2b–NH_4 conversion

Fig 3 – ^{15}N tracing model (Müller et al.,2007)



Results:



a. Urea hydrolysis was rapid for all treatments (no hydrolysis effect detected after 24 hrs)

b. The model indicated n-BTPT treatments had no effect on reducing the rate of urea hydrolysis (H_u)

c. Treatments with DCD indicated decreased rate of net NO_3 production ($O_{NH4} + O_{Nrec} - I_{NO3} - D_{NO3}$)

d. DCD treatments showed increased mineralisation of recalcitrant N, but these rates of increase are low

e. Higher rates of immobilisation of labile NH_4 (I_{NH4_Nlab}) were indicated in the DCD treatments

f. Increased rates of dissimilatory NO_3 reduction were modelled in treatments with DCD

Discussion and Summary:

- Due to rapid urea hydrolysis and the time-lag required for the conversion of n-BTPT to its oxygen analogue (which is the active urease inhibitor), the liquid application of n-BTPT was ineffective at delaying the rate of urea hydrolysis.
- DCD was highly effective in reducing oxidation of NH_4 and net NO_3 production.
- Treatments with DCD had several non target effects such as increased rates of immobilisation of labile NH_4, mineralisation of recalcitrant N and dissimilatory NO_3 reduction

References:

Stevens, R.J., Laughlin, R.J., 1994. Determining N-15 in nitrite or nitrateby producing nitrous-oxide. Soil Science Society of America Journal 58, 1108–1116. Laughlin, R.J., Stevens, R.J., Zhuo, S., 1997. Determining nitrogen-15 in ammonium byproducing nitrous oxide. Soil Science Society of America Journal 61, 462–465.

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