GRASSLAND MANAGEMENT: IMPACTS ON THE ENVIRONMENT

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Introduction

Grasslands dominate much of the European landscape, occupying 22% of the land area in the 25 countries of the EU. Their management therefore influences a range of environmental impacts, particularly since some grasslands receive large inputs of nutrients. This paper explores the environmental consequences of different fertilizer and manuring strategies for a cut grassland by using the DNDC (DenitrificationDecomposition) model at the Bush Estate, near Edinburgh. This model simulates daily fluxes and pool sizes of carbon and nitrogen in agroecosystems. It has been extensively applied around the world and is widely acknowledged as a state-of-the-art model for assessing nutrient fluxes (Li et al., 2006; Saggar et al., 2004).

Methodology

Measurements of CO_2 and N_2O emissions have were made at Bush estate between 2002-2004. Applications of 300 kg available N ha^{-1} of fertilizer or slurry were applied and three silage cuts were taken each year (Jones et al., 2007). In addition to the fertilized plots, there was a control plot which received no fertilizer N. DNDC was used to model nutrient exchange and turnover. The model's input variables were daily climate, soil properties and management activities. The outputs included soil organic carbon storage, nitrate leaching and greenhouse gases; namely CO_2 and N_2O. The model was run for six years, with the results presented for the period 2002-2003.

Results

There was a tendency for the model to under predict CO_2 and N_2O emissions for the control plots, while the predictions for the ammonium nitrate fertilizer showed the expected trends, Fig 1.

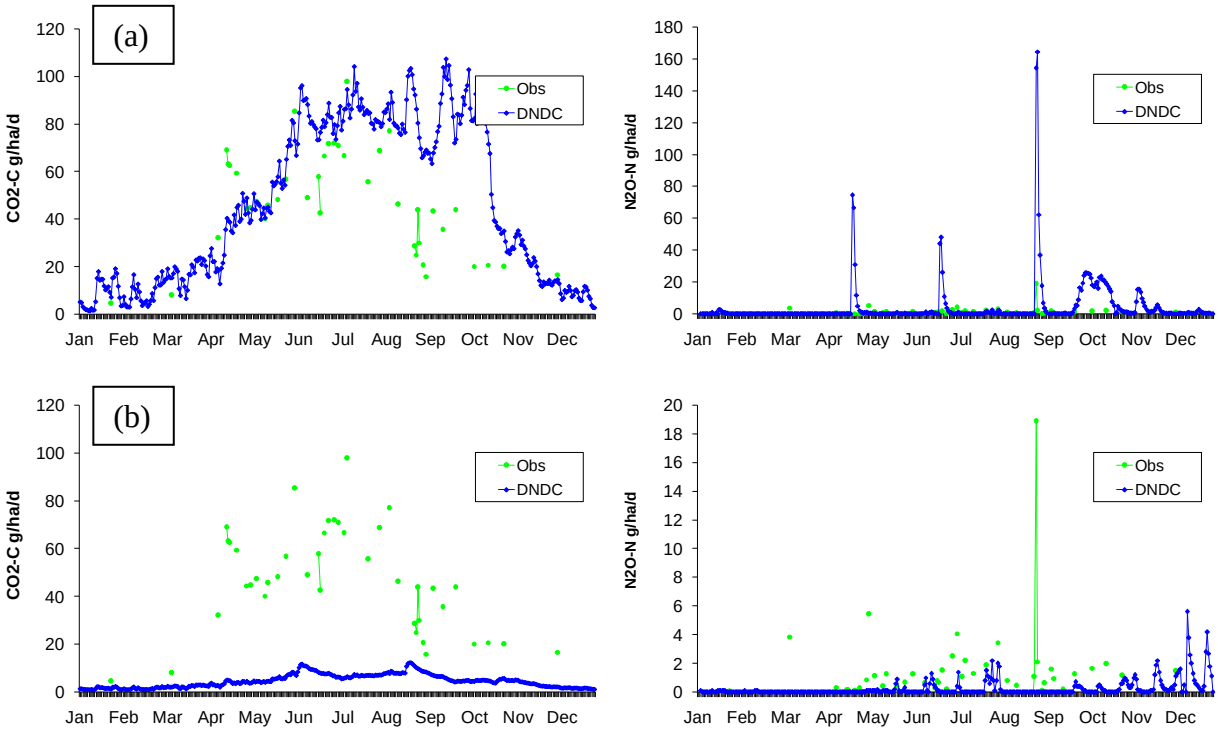

Fig 1. Comparison of CO_2 and N_2O for 2003 for the ammonium nitrate fertilizer application (a) and the control plots (b).

The results suggested that the addition of manure increased the soil organic carbon compared with the inorganic N and control treatments (Fig 2a). This was consistent with measurements made at the site (Jones et al, 2005). However, the global warming potential (GWP), expressed as CO_2 equivalents, of the plots receiving cattle slurry were larger than the fertilized plots ($P< 0.05$), and the control plot had a slightly negative GWP due to carbon sequestration. As expected applications of cattle slurry resulted in larger NO_3-N leaching than the plots receiving inorganic N fertilizers partly as a consequence of the larger N input associated with the slurry (Fig 2b). The N_2O emissions were higher for urea fertilizer than ammonium nitrate fertilizer. As with the GWP potential, the N_2O emissions were highest for the cattle slurry.

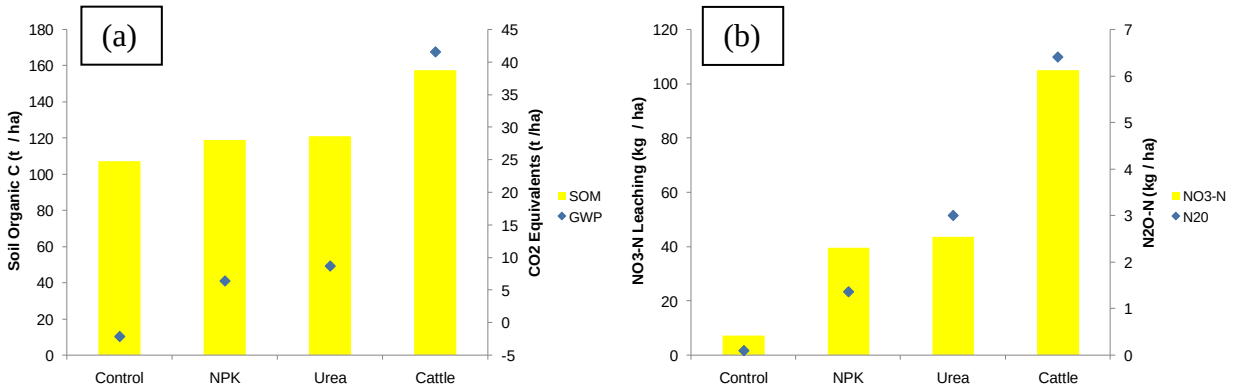

Fig 2. Simulations of annual average nutrient flows in for three different manure / fertilizer strategies at Bush estate, Edinburgh. All fluxes were averaged over the period 2002-2003. (a) The final soil organic carbon content (kg/ha to a depth of 50 cm) and the GWP; (b) Nitrate leaching (below 50 cm) and nitrous oxide emission.

Conclusions

The high application rates of the cattle slurry resulted in high levels of organic-N within the soil, which was not mineralized as quickly as the model predicted and was thus not taken-up by the crop. This may have resulted in losses of N_2O being overestimated. In addition, from Fig. 1, it would be expected that the GWP of the plots receiving no fertilizer or manure would be substantially higher than predicted by the model. Nevertheless, the results obtained can be valuable in helping understand the mechanisms underlining the observed management effects and in highlighting interactions and synergies. Although there were some weaknesses in the ability of DNDC to simulate the emissions from the grassland site used in this study, the results reveal that there is value of a systems based modelling approach to the study of environmental impacts. Confidence in such modelling approaches needs to be established through a careful process of validation. Data are being collected from additional sites, a grazing trial and a six-course organic rotation; these will aid in understanding the mechanism, and therefore help improve the modelling process.

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