The effect of ploughing intensity on grassland CO_2 and N_2O fluxes

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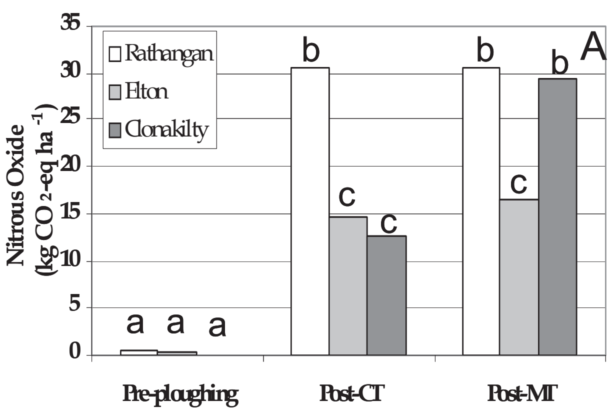
Introduction The effects of land-use change on greenhouse gas fluxes are considered to be significant with the conversion of grassland to annual or perennial cropland estimated to release up to 2 tonnes CO_2 ha^{-1} yr^{-1} (Lal 2003, Ogle *et al.* 2004). However, a large degree of uncertainty is associated with these estimates, and the transition phases between land-uses, in particular, are poorly quantified. In addition, the intensity of soil cultivation may affect emissions of both CO_2 and N_2O via alterations to both soil carbon (C) and nitrogen (N) turnover and balances. The objective of this study was to to quantify and compare the greenhouse gas (GHG) fluxes following conventional ploughing (CT) and minimum tillage (MT) on three different soil types in a small scale lysimeter study in Johnstown Castle, Wexford in order to assess the environmental impact of this step of the land use change process.

Materials and methods The study was carried out on isolated *Lolium perenne* lysimeters (diameter 0.75m, depth 1m) of three different soil drainage classes: Poorly-drained (Rathangan), medium-drained (Clonakilty) and well-drained (Elton). Three lysimeters of each soil type were subsequently either manually inversion-ploughed to 30cm or minimum-tilled to 10cm using a trowel, . Measurements of soil CO_2 respiration and N_2O flux were measured for 22 days pre- and post-disturbance using static chambers temporarily placed over the lysimeters. CO_2 respiration was measured with chambers connected to an infra-red gas analyser (EGM-4, PP Systems, Hitchin, Herts. UK), and fluxes were calculated from the rate of CO_2 concentration increase over a three minute period. Gas samples for N_2O analysis gas were taken from each chamber over intervals of 30–45 min. These samples were subsequently analysed the using a Varian 3300 GC with electron capture (ECD) detector. Analysis of variance procedures were conducted and least significant difference (LSD) calculated using SAS 3.0 (SAS Institute, Cary, NC) .

Results The effects of tillage intensity on both N_2O and CO_2 fluxes are shown in Figure 1. Nitrous oxide emissions increased substantially following ploughing, with emissions from the poorly-drained soil (Rathangan) 100% higher than the better-drained soils after inversion ploughing. Tillage intensity significantly affected fluxes ($p<0.01$) for the medium-drained (Clonakilty) soil, with cumulative emissions increasing from 13 kg CO_2-eq ha^{-1} to 29.8 kg CO_2-eq ha^{-1}. Increases in soil respiration post-disturbance were transient and no significant effects were observed except for the Clonakilty soil, where a small, but significant increase was observed after inversion ploughing ($p > 0.05$).



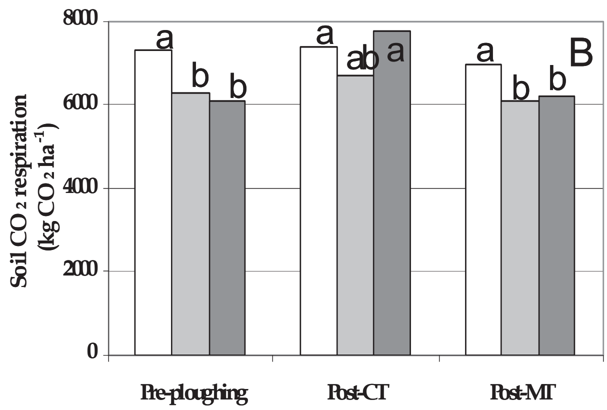


Figure 1 Cumulative fluxes of A) Nitrous oxide and B) soil CO_2 respiration on lysimeters (n=3) over 22 days before and 22 days after conventional inversion ploughing (CT) and minimum tillage (MT). Different letters indicate significant differences ($p > 0.05$).

Conclusions Post-cultivation, CO_2 emissions were only higher for the Clonakilty soil, whereas N_2O emissions remained high over a prolonged period of time for all soil types. The differences in N_2O fluxes in terms of both ploughing intensity and soil type were probably driven by differences in soil moisture conditions. Initial increases in soil respiration were possibly due to degassing of CO_2 trapped in the soil pore spaces. However, sustained increased fluxes, that are predicted by biogeochemical models were not observed.

Acknowledgements The authors gratefully acknowledge funding under the DAFF Research Stimulus Fund

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https://doi.org/10.1017/S2040470010002219 Published online by Cambridge University Press