

The effect of ploughing intensity on grassland CO₂ and N₂O 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 CO₂ 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 CO₂ and N₂O via alterations to both soil carbon (C) and nitrogen (N) turnover and balances. The objective of this study was 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 CO₂ respiration and N₂O flux were measured for 22 days pre- and post-disturbance using static chambers temporarily placed over the lysimeters. CO₂ 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 CO₂ concentration increase over a three minute period. Gas samples for N₂O analysis were taken from each chamber over intervals of 30–45 min. These samples were subsequently analysed 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 N₂O and CO₂ 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 CO₂-eq ha⁻¹ to 29.8 kg CO₂-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 ($p > 0.05$).

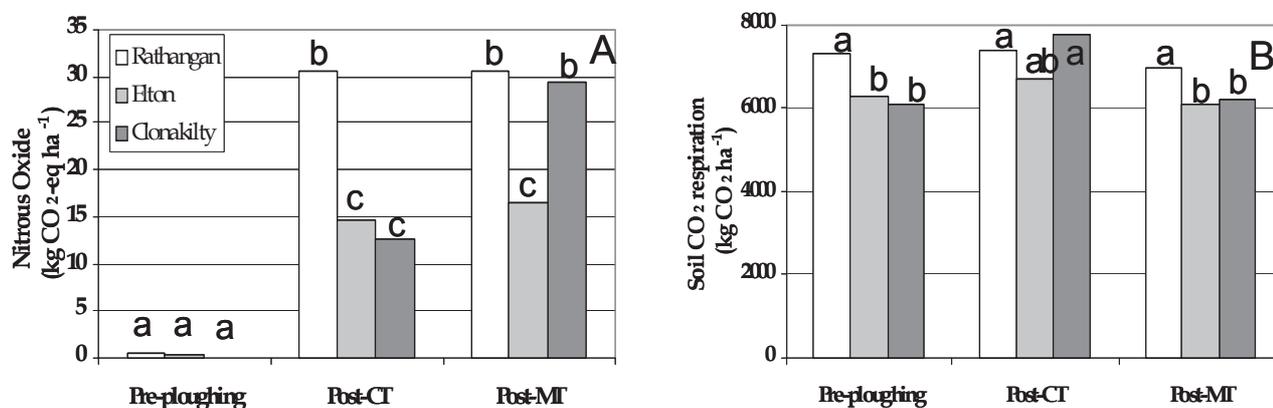


Figure 1 Cumulative fluxes of A) Nitrous oxide and B) soil CO₂ respiration on lysimeters (n=3) over 22 days before and 22 days after conventional inversion ploughing (CT) and minimum tillage (MT). Different letters indicate significant differences ($p > 0.05$).

Conclusions Post-cultivation, CO₂ emissions were only higher for the Clonakilty soil, whereas N₂O emissions remained high over a prolonged period of time for all soil types. The differences in N₂O 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 CO₂ trapped in the soil pore spaces. However, sustained increased fluxes, that are predicted by biogeochemical models were not observed.

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References

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