An examination of the diurnal variability in nitrous oxide emissions

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Keywords: diurnal variability, nitrous oxide, temperature

Introduction It is generally assumed in field experiments, that the measurement of nitrous oxide (N_2O) using enclosed chambers for a period of 1 hour can be used to provide an estimate of daily emission rates. In the majority of studies, emission measurements are conducted between 0900 and 1300 h. However, clearly defined diurnal cycles in N_2O emission rates have been observed from both agricultural and forest soils in temperate regions as a consequence of diurnal fluctuations in temperature (Blackmer *et al*., 1982; Ball *et al*., 1999; Baggs *et al*., 2002). The objective of this study was to quantify the diurnal variation in N_2O emissions from a grassland soil receiving two rates of nitrogen (N) fertiliser inputs under ambient spring and summer conditions.

Materials and methods A system of six mini-lysimeters was constructed using soil cores (150 mm in diameter and 100 mm deep) taken from a perennial ryegrass sward (*L. perenne* cv Tyrone). Two N treatments were imposed at rates equivalent to 100 and 150 kg N/ha 2 days before the start of the measurement period. The study was undertaken during the spring and summer of 2003. Emission measurements were undertaken on a 2-hourly basis for 2 full days (i.e., 48 hours) in each experimental period. Nitrous oxide concentrations were measured using gas chromatography. Soil surface and air temperature were monitored throughout. The effect of N treatment on diurnal emission rates in both spring and summer was explored using residual maximum likelihood variance components analysis (REML). Pearson correlation coefficients were used to identify relationships between N_2O emissions and temperature.

Results Clearly defined diurnal cycles were identified in both experimental periods which were not affected by N treatment. There were significant differences in emission rates between N treatments within each period. Diurnal variations in N_2O emission rates in spring were markedly out of phase with diurnal variations in soil temperature with minimum and maximum emission rates occurring at midday and night-time, respectively. Minimum and maximum N_2O emission rates as measured on day 1 were 67 and 117 µg N_2O-N /m^2/h, respectively, at 100 kg N/ha and 49 and 61 µg N_2O-N /m^2/h, respectively at 150 kg N/ha on day 1. Minimum and maximum emission rates on day 2 were 70 and 353 µg N_2O-N/m^2/h, respectively, at 100kg N/ha and 48 and 220 µg N_2O-N/m^2/h, respectively, at 150 kg N/ha. Correlations were weak and negative and non-significant at the 95% confidence interval. Soil moisture content and soil mineral N status would appear to have been the overriding contributing factors. In contrast, N_2O emissions followed diurnal variations in soil temperature with a time-lag of four hours between maximum soil temperature and maximum emission rates during the summer measurement period. Maximum emission rates were found in early afternoon with minimum emission rates occurring in early morning. Minimum and maximum N_2O emission rates, as measured on day 1, were 1361 and 5952 µg N_2O-N/m^2/h, respectively, at 100 kg N/ha and 3171 and 6582 µg N_2O-N/m^2/h, respectively at 150 kg N/ha. Minimum and maximum emission rates on day 2 were 318 and 2230 µg N_2O-N/m^2/h, respectively, at 100kg N/ha and 1123 and 5040 µg N_2O-N/m^2/h, respectively, at 150 kg N/ha. Correlations with temperature were positive and significant at the 95% confidence interval.

Conclusions The diurnal variations in N_2O emission rates observed were due to temperature, soil moisture content and mineral N status. The variations observed confirm the difficulties in assessing daily emission values based on a single measurement for a short period during the 24-hour day. However, this is often the only logistically feasible approach in large scale-field experiments. Low cost methodologies need to be developed which enable the continuous measurement of N_2O emission rates using enclosed chambers.

Acknowledgements This work was part funded under the Irish Government's ERTDI programme 2000 – 2006.

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