Effects of pH and disturbance on nitrous oxide emission from arable soil - a role for fungal denitrification?

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Denitrification is the biological process by which intermediates of the N cycle are reduced to maintain respiration under oxygen limiting conditions. Incomplete denitrification results in the release of the greenhouse gas nitrous oxide (N_2O). Bacteria are considered to play a predominant role in denitrification, but the contribution of fungi remains poorly understood. Here we test the hypothesis that fungi contribute significantly to N_2O emission in arable soil and that the fungal contribution is higher in low pH soil.

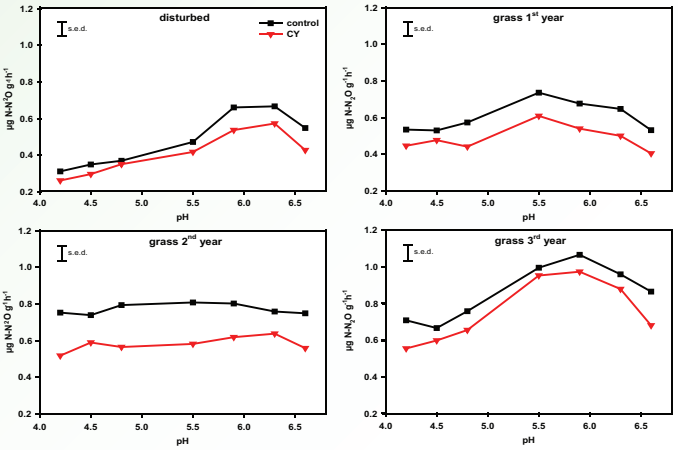
Material and Methods

Soil was sampled from long-term pH plots under crop rotation. Seven different pH and four disturbance treatments were sampled. Potential denitrification rates (PDR) were measured in microcosms. Distinction between bacterial and fungal denitrification was attempted through application of selective biocides (cycloheximide (CY) to suppress fungal, streptomycin (S) and chloramphenicol (CH) to suppress bacterial activity). Ester linked fatty acids (ELFA) were extracted and used to evaluate the fungal to bacterial ratio and microbial community composition.

Sampling site at SAC Craibstone Estate

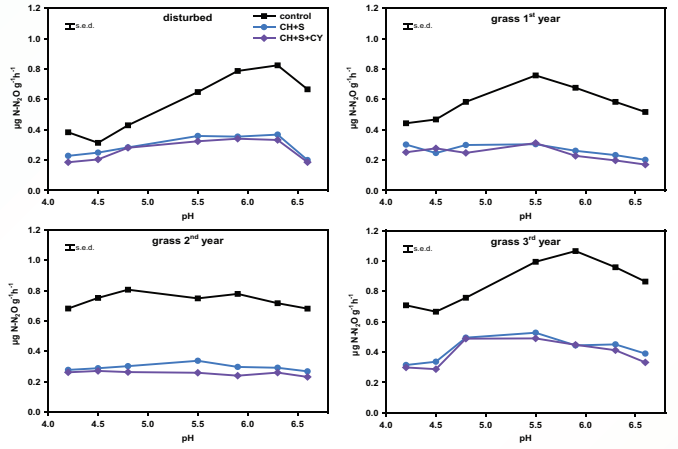
Results

Effect of cycloheximide on denitrification



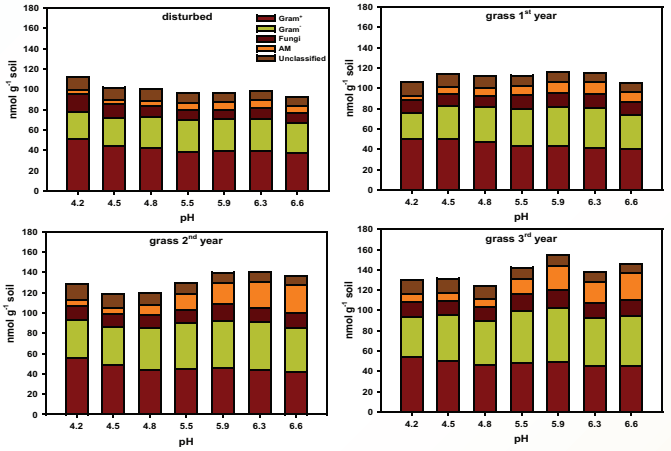
CY reduced the PDR significantly ($p < 0.001$). The average inhibition was 20%. Soils showed optimum pH for denitrification at around pH 6. PDR were lower at low pH.

Effect of antibiotics on denitrification



The PDR were significantly reduced by the application of all antibiotics ($p < 0.001$). There was no significant difference between the CH+S treatment and the CH+S+CY treatment.

ELFA of classified and unclassified microbial biomass



Total microbial biomass increased in less disturbed soil. Fungal and total bacterial biomass were not influenced by pH. The ratio of fungal to bacterial biomass remained constant with pH and disturbance.

Table: Fungal to bacterial ELFA-ratios over pH and disturbance gradient. (Data show mean ratios ± standard deviation)

Management	pH 4.2 ± 0.1	pH 4.5 ± 0.1	pH 4.8 ± 0.1	pH 5.5 ± 0.1	pH 5.9 ± 0.1	pH 6.3 ± 0.1	pH 6.6 ± 0.1
disturbed	0.20 ± 0.109	0.17 ± 0.040	0.14 ± 0.003	0.12 ± 0.009	0.11 ± 0.009	0.14 ± 0.050	0.13 ± 0.001
grass 1st year	0.14 ± 0.002	0.12 ± 0.006	0.12 ± 0.000	0.15 ± 0.001	0.15 ± 0.021	0.16 ± 0.019	0.15 ± 0.020
grass 2nd year	0.12 ± 0.006	0.13 ± 0.005	0.13 ± 0.004	0.13 ± 0.003	0.16 ± 0.000	0.14 ± 0.014	0.16 ± 0.031
grass 3rd year	0.14 ± 0.006	0.13 ± 0.000	0.13 ± 0.013	0.15 ± 0.027	0.15 ± 0.013	0.14 ± 0.000	0.15 ± 0.003

Conclusions

- Fungi contribute significantly to denitrification in arable soil.
- The proportion of fungal PDR is constant over the pH gradient.
- Fungal activity seems to be influenced by bacterial inhibitors.
- Potential denitrification rates are lower at low pH.
- Lower denitrification could be due to lower microbial biomass.
- The composition of the microbial ELFA cannot be directly related to PDR.
- The fungal to bacterial ratio is not influenced by pH.

Acknowledgments

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