Linking root traits and N_2O emissions from grassland soils

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Background

Nitrous oxide (N_2O) contributes about 6% to the anthropogenic greenhouse effect and it has approximately 300 times the global warming potential of CO_2 on a mass basis (IPCC 2014). Agriculture is a major source of N_2O emission, accounting for approx.. 80% of the total anthropogenic emission in the world (IPCC 2014). Use of plant community composition with different plant and root traits has been shown a great strategy to reduce N_2O fluxes and to promote better nitrogen utilization in the soil.

Objective

The aim of this study is to investigate the link between root traits and N_2O fluxes, in particular, how plant species with different functional group related to root system affected N_2O fluxes and productivity in fertilised grasslands.

Methods

- The field experiment consisted of 21 plots (7 treatments and 3 reps): monocultures of two grasses (*Lolium perenne* and *Phleum pratense*), two legumes (*Trifolium pratense* and *Trifolium repens*) and two forbs (*Plantago lanceolata* and *Cichorium intybus*), and a six-species mixture (Fig. 1).
- N_2O fluxes were measured using photoacoustic infrared spectroscopy GaseraOne, everyday in the first week, then 3x a week totaling a month of measurements.
- Soil N_2O concentration was measured using diffusion probe once a week at different soil depth: 0-5 cm, 5-10 cm, 10-20 cm and 20-30 cm (Fig. 2).
- Roots were collected at the end of the experiment to measure root biomass and traits at two different depths (0-10 cm and 10-30 cm). The root traits measured were root length density (RLD) and specific root length (SRL).

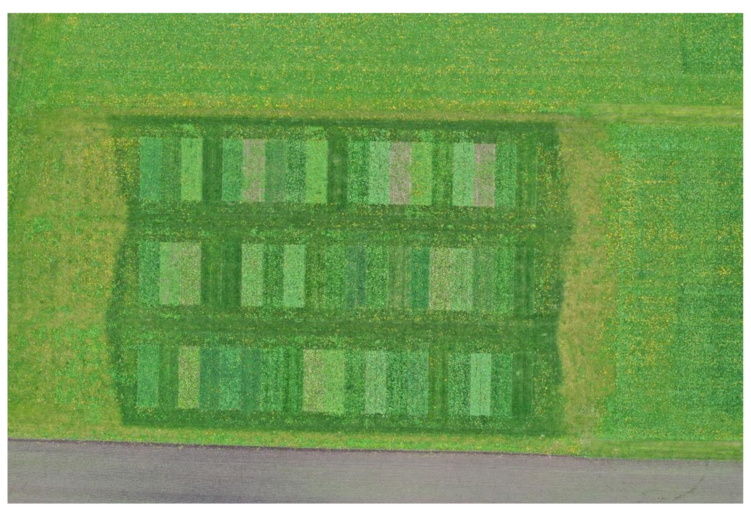

Figure 1. Layout of the field experiment, Foulum, Aarhus University, Denmark.

Figure 2. Detail of the needles used to collect N_2O concentration in the soil profile.

Findings

- There was an immediate step increase in N_2O fluxes from the soil soon after the rainfall simulation. Mean N_2O emission peaks reached 544 and 283 ug N_2O m^{-2} h^{-1} at 9 and 12 days after nitrogen application, respectively.
- There was no difference in daily and cumulative N_2O emissions between functional group, and plant species composition. Although legumes (*T. repens*) showed the greatest N_2O emissions, it was not statistically significant.

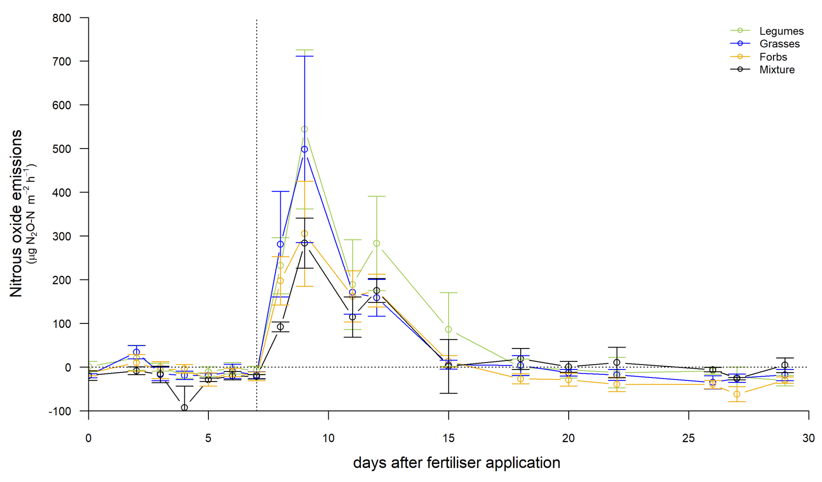

Figure 3. N_2O emission from the soil following fertiliser application to the field experiment. Arrow indicates rainfall event simulation. Vertical bars show ± standard error (n = 3).

Species composition	Mean		SE
T. repens	61.9	±	35.1
L. perenne	33.0	±	6.5
P. lanceolata	13.9	±	7.9
Six-species mixture	12.5	±	7.3
P. pratense	1.1	±	9.5
T. pratense	-1.6	±	14.4
C. intybus	-3.1	±	16.1

Table 1. Cumulative N_2O emissions for each plant species composition and the six-species mixture.

- T. *repens, P. pratense* and *C. intybus* showed a gradually increasing N_2O concentration of the profile with soil depth.

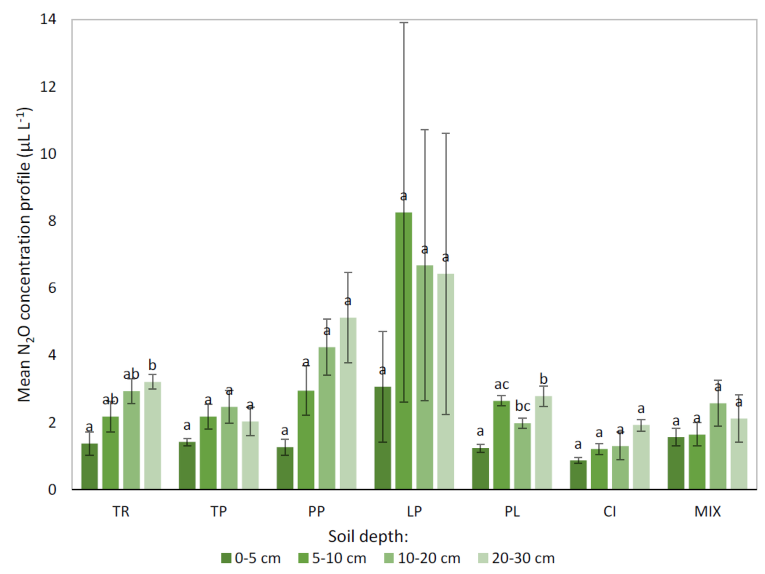

Figure 4. N_2O concentration at different soil depths of the six plant species. Vertical bars show ± standard error (n = 3). Letter above the bars shows the differences of the N_2O concentration between different soil depth.

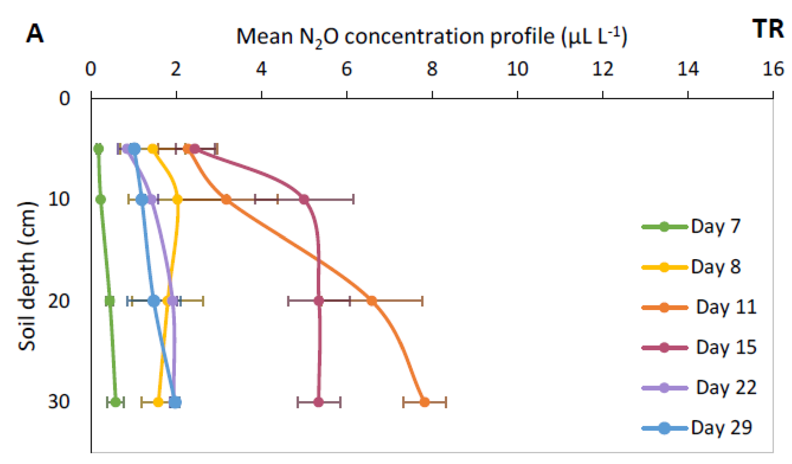

Figure 5. N_2O concentration in the profile over time for *T. repens* at different soil depths. Horizontal bars show ± standard error (n = 3)

- There was a significant correlation between root traits; higher RLD and SRL at deeper soil layer, higher N_2O concentration in the profile.
- Higher root N uptake at deeper soil layer, lower cumulative N_2O emissions.

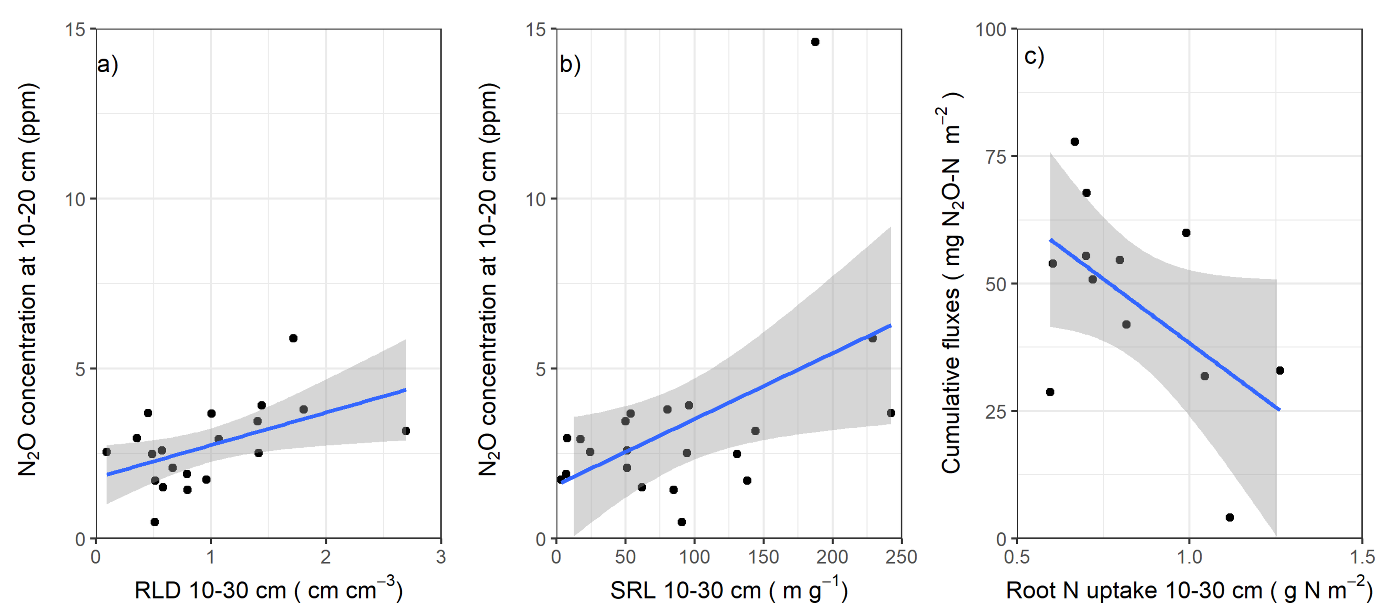

Figure 6. Relation between N_2O and root traits: a) N_2O conc. at 10-20 cm depth and root length density (RLD) at 10-30 cm, b) N_2O conc. at 10-20 cm depth and specific root length (SRL) at 10-30 cm, and c) cumulative N_2O emissions and root N uptake at 10-30 cm depth.

Conclusions

Our results showed that root traits of grassland species is great linked to N cycling, in particular, N_2O concentration and fluxes from the soil. This represent a great align as management tool to fight against climate change.

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