Project Title: Exploring Mitigation of Nitrous Oxide (N_2O) Emissions from Grasslands by Rhizobia Inoculation

Lead Institution/Department: University of Bristol, School of Geographical Sciences
Primary Supervisor: Dr Fotis Sgouridis
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Co-Supervisor: Dr Tom Williams, School of Life Sciences
Co-Supervisor: Prof Sami Ullah, School of Geography Earth and Environmental Sciences, University of Birmingham

Scholarship: A fully funded PhD studentship including UK fees, annual stipend, and a research budget, is available at the University of Bristol. Study will begin in September 2025 and is funded for four years. The deadline for applications is 31st January 2025.

Project background
Nitrous oxide (N_2O) is a potent greenhouse gas with ~300 times the warming potential of carbon dioxide, and its concentration has increased by more than 20% from 1750 to 2019. Agriculture is the largest source of anthropogenic N_2O, contributing 70% to total emissions. More than half of the agriculturally emitted N_2O (4.1 Tg N_2O-N) is coming from permanent grasslands and 86% of it from intensively managed fertilised grasslands. Mitigation measures that reduce N_2O emissions from agriculture are urgently needed and can make the difference in combating climate change. Manipulating the soil microbiome could hold the key to reducing N_2O emissions without sacrificing agricultural production. Symbiotic Rhizobia that are N-fixers and form nodules in the roots of clover plants, consistently sown in grassland swards, could be capable of also reducing N_2O if they possess the gene for encoding nitrous oxide reductase (nosZ). This genotype has been shown to exist in soybean-rhizobia associations, but little is known on whether clover-rhizobia symbionts can display similar N_2O reducing capabilities. There is a huge unexplored potential for N_2O reduction in the 40% of global land surface covered by permanent grasslands if we can discover the right rhizobial strains for inoculation!

Project aims and methods
This project will investigate the potential of clover-rhizobia associations to mitigate N_2O emissions from grassland soils. The PhD student will initially screen different types of UK grassland soils and isolate native rhizobia strains to investigate the presence of the N_2O-reducing genotype. These strains will undergo DNA extraction and genomic sequencing. The presence of the nosZ gene will be confirmed and compared with known positive and negative control rhizobial strains. Biogeochemical analysis of the parent soil material will be related to the presence/absence of the nosZ gene sequence to infer potential genotype environmental controls. The PhD student will be supported for this part of the project by the UoB Genomic Facility and Bioinformatics suite. At the next stage, the identified nosZ+ rhizobial strains will undergo a phenotype assessment and mechanistic understanding of N_2O reduction. A series of invitro incubations of cultured rhizobia will be set up and supplied with stable isotope labelled gases ($^{15}N_2$ & $^{15}N_2O$) to elucidate specific pathways of N_2O production and reduction by stable isotope probing. This work will be supported by the Environmental Stable Isotope Laboratory at the SoGS. The final stage of the PhD will focus on testing the capacity of the N_2O-reducing rhizobia to mitigate N_2O emissions in a soil-plant-atmosphere mesocosm experiment simulating field conditions. The experiment will be

set up at the specialised GroDome facility at the School of Life Sciences. The identified rhizobia will inoculate red and white clover seedings grown under a multi-factorial potting experiment testing different grassland sward compositions and fertilisation regimes. N_2O emissions will be measured regularly during the plant growth via gas chromatography, while plant health will be assessed via photophysiology measurements using Pulse Amplitude Modulation (PAM) fluorimetry. At the end of the growth period, N_2 fixation activity will be measured after harvesting the clover plants, using the ^{15}N natural abundance method.

Candidate Requirements
This project would suit an outstanding candidate with some knowledge of molecular biology techniques and statistical analysis. Knowledge of bioinformatics would also be desirable. No prior knowledge of biogeochemistry analytics is required. We welcome and encourage applications from under-represented groups.

Training
You will receive extensive training in DNA extraction and amplification techniques, genomic sequencing and bioinformatic analysis. You will also be trained in biogeochemical analysis of soils and the use of mass spectrometry for stable isotope analysis in gas and solid samples. You will emerge with a strong background in interdisciplinary sciences, including the application of molecular analysis to answer environmental sciences problems. A demonstrable track-record in highly marketable transferable skills, such as lab analytics, coding, numeracy, written and spoken presentation, and an ability to work effectively within a multidisciplinary team will also be developed. You will have opportunities for overseas travel for networking (conferences).

Useful Links

https://www.bristol.ac.uk/geography/courses/postgraduate/

https://www.bristol.ac.uk/study/postgraduate/research/geographical-sciences-physicalgeography/

How to Apply: Please apply to the “Geography (PhD)” programme at https://www.bristol.ac.uk/study/postgraduate/apply/

Please contact f.sgouridis@bristol.ac.uk for informal enquiries.

The application deadline is **31st January 2025.**