



FELLOWSHIP SUMMARY REPORTS

Fellow's name: María T. Domínguez (Instituto de Recursos Naturales y Agrobiología de Sevilla / University of Sevilla, Spain)

Theme number: Theme 1 (Managing natural capital for the future)

Project title: Impact of drought on soil biogeochemical cycling: regulation of microbial growth efficiency by soil moisture and substrate supply

Host institution: Utah State University (USA)

Host collaborator: Prof. John Stark

Dates of fellowship: 1 June 2017 - 28 July 2017

I give my consent to the publication of this report on the Co-operative Research Programme's website

1. Objectives of the research project

The project aimed to characterize microbial Carbon Use Efficiency (CUE) in soils from pastures with different plant composition in the Cache Valley of Northern Utah (USA), and to evaluate the effect of soil drying on CUE. This aim fits the general objective of a broader research project sponsored by the USDA National Institute of Food and Agriculture, that compares soil C cycling in soils from legume pastures (dominated by Birdsfoot trefoil) and from grass pastures (meadow brome, *Bromus* spp.), with the aim of elucidating whether the conversion of grass pastures into Birdsfoot trefoil legume pastures could contribute to mitigate CO₂ emissions from grazing areas.

2. Relevance of the topic

The mineralization of soil organic matter by microbes results in CO₂ production (soil respiration), which represents a major flux of C to the atmosphere. Understanding the key regulators of soil respiration is therefore critical to formulate predictions of C sequestration under different land-use or climate change scenarios. The microbial Carbon Use Efficiency (CUE) is a physiological parameter that directly controls the short-term rates of CO₂ production, with higher CUE promoting a higher sequestration of C into microbial biomass.

In pasture lands, soil CUE might be affected by a range of factors including soil moisture and the composition of the plant community, which supplies C substrates to soil microbes. Promoting those practices that enhance C sequestration into microbial biomass would contribute to mitigate the large GHG emissions derived from the livestock industry in the USA. Emissions derived from beef production have been estimated to account for about one-third of USA agricultural greenhouse gas GHG emission. If soils from legume pastures have a greater CUE than those from grass pastures, then there might be an opportunity to increase potential soil C sequestration in grazing lands by promoting the abundance of legume species over grass species.

3. Objective achievement

The objectives were partly achieved. On one hand, the fellow participated in an incubation experiment with soils from the experimental farm, where CUE was analyzed in soils supplied with different C substrates and exposed to different water regimes. In these soils, extractions of microbial biomass, microbial lipids and microbial DNA were performed after adding pulses of ¹³C-labelled substrates, as part of the analysis of the allocation of C into different microbial C pools. Isotopic analysis in these extractions is currently ongoing.

On the other hand, one of the aims of the project proposal (characterizing CUE in the experimental soils *in-situ*, by measurements of ¹³CO₂ production from the intact soils by cavity ring-down spectroscopy) could not be achieved for technical reasons. The equipment needed for this purpose was a new acquisition in the host laboratory and equipment calibration and set-up was not still ready for in-situ applications.

4. Major achievements of the fellowship

The three major achievements of the fellowship were:

1. Participation in the experimental set-up, so the fellow could get familiar with the techniques used by the host group to perform ¹³C labelling studies. This will be highly helpful for the implementation of future experiments involving the use of isotopic techniques at the fellow's home institution.
2. Set-up of the methodology for lipid analysis in the host laboratory. Phospholipid and neutral fatty acids are important components of the microbial cells, where they function as structural components of the cell membranes and C-storage compounds, respectively. The methodology for lipid extraction and fractionation was new to the host lab, and has been implemented in this lab by the fellow during the fellowship period. Analysis of ¹³C in these specific compounds is been conducted to elucidate whether



the ^{13}C applied during the experiment is being allocated as storage compounds C within microbial cells or invested in microbial growth. These analyses will allow for a more detailed analysis of the processes behind C sequestration into microbial biomass.

3. Collaboration with another laboratory in the host institution to conduct soil DNA extractions. With the same experimental soils, DNA extractions were performed as the first step in the analysis of the allocation of the added ^{13}C into different functional groups within the soil microbiome. The fellow conducted these extractions at the Dr. Norton's lab at Utah State University, getting the opportunity to get familiar with these molecular techniques.

5. Follow-up

Analyses of C isotopes in the mentioned extracts are being currently conducted. It is expected that the results of this incubation experiment will be prepared for publication in a top-ranked scientific journal, such as Soil Biology and Biochemistry or Applied Soil Ecology, as a collaboration between the two institutions involved.

This fellowship strengthened the ongoing cooperation between these two institutions. This cooperation started in 2014 thanks to a six-month stay of Prof. Stark at the Institute of Natural Resources and Agrobiological Sciences (Spain), when he contributed to the implementation of the methodology for CUE analysis at this institution. This fellowship provided the opportunity to acquire a deeper knowledge about the methodology for CUE analysis, which I expect to apply back in Spain.

6. Relevance to agro-food, fisheries or forestry policies

The fellowship was conducted in the framework of a broader research project dealing with the factors determining microbial CUE in pasture soils from Western USA. This project aims to improve the understanding of controls over CUE in these agroecosystems, providing essential information to increase C-sequestration and reduce greenhouse gas production from pasture lands in the USA, therefore information to be obtained is relevant to decision-making in relation to the sustainable use of grazing lands in the USA.

The topic falls within one of the priorities of the USDA's Agriculture and Natural Resources Science for Climate Variability and Change Challenge Area Program ("Climate and Microbial Processes in Agroecosystems").

7. Relevance to the CRP

The topic of the research project is highly relevant to the general aim of the Co-operative Research Programme. The microbial growth efficiency is one of the first and most important regulatory points in the sequence leading to sequestration of labile organic C into more complex organic compounds. By evaluating the impact of different grazing systems and soil moisture on this physiological parameter we expect to demonstrate that legume pastures might enhance soil carbon sequestration by promoting a higher efficiency in the use of labile C by soil microorganisms. This information could support decision-making in relation to the sustainable use of grazing lands in the USA. Areas devoted to cattle grazing represent a 26 % of surface land in USA, and therefore changes in the management of these systems may pose large changes in regional and national soil C stocks. For the same reasons, the topic is highly relevant for programme's Theme 1 (Managing natural capital for the future).

8. Satisfaction

The fellowship met my expectations. I had the opportunity to gain expertise and training in stable isotope labelling techniques, which I expect to apply at different projects currently on going at my home institution. Also, the fellowship helped me to consolidate my collaboration with Prof. Stark's group. As a young researcher trying to consolidate an independent research line these fellowships are very useful to get familiar with novel techniques and incorporating new ideas for my own research. Management of the fellowship paperwork worked really well, and communication with OECD staff was quick and easy. Besides some



technical problems with some equipment, I did not encounter any practical problems. I would suggest increasing the fellowship budget for stays at the USA, as costs derived from visa and medical insurance requirements summed a significant fraction of the grant.

9. Advertising the Co-operative Research Programme

I learnt about the Co-operative Research Programme from a colleague who got one of these fellowships few years ago. My feel is that these fellowships are becoming more visible in the last years; this year I have seen them advertised through different mailing lists.

