Root exudation and nutrient dynamics under elevated CO2

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Introduction

- Plant roots release a variety of low-molecular-weight organic compounds into their immediate soil environment. These exudates mediate biological and chemical interactions between plants, soil and microorganisms.
- Previous research has found that elevated levels of carbon dioxide (CO2) increase the rate of root exudation.
- However, little is known about the effect of elevated CO_2 on the composition of root exudates and, in turn, its effect on nutrient dynamics.
- Existing studies are either performed in laboratory conditions, which may not be representative of mature ecosystems, or only quantify the total amount of carbon released, which does not allow for detailed analyses.

The aim of this project is to determine the composition of root exudates and its effect on nutrient dynamics in a mature forest ecosystem under elevated CO2 *in-situ*, using novel approaches in rhizosphere biology and plant metabolomics.

Study site

Figure 1. Aerial view of BIFoR FACE

BIFoR FACE (Free Air Carbon dioxide Enrichment) experiment, located in Staffordshire, has been running since August 2016. The site is a temperate deciduous forest, with dominant *Quercus robur*.

The planned experiment will be conducted in 3 plots with elevated levels of CO_2 (+150 ppm above ambient levels) and 3 plots with ambient levels of CO_2.

Figure 2. CO2 fumigation at BIFoR FACE

Research questions

1. What is the composition of root exudates of *Quercus robur* at BIFoR FACE?
2. Is there a significant difference between elevated and ambient CO2 plots in the rate and chemical composition of root exudation of *Quercus robur*?
3. Do differing root exudation patterns affect tree nutrient availability?
4. Do differing root exudation patterns affect nutrient uptake by trees?

Methodology

(1-2) Root exudate composition will be determined through metabolomics analyses (Fig.3). Samples will also be analysed for total organic carbon (TOC). Sampling will be performed using a culture based method developed by Phillips et al. (2008), whereby exudates are collected in a solution medium following an incubation period.

(3) The effect of differing root exudation patterns on nutrient availability will be determined through (1) compound addition experiments on soil samples collected from BIFoR FACE and (2) statistical analyses of the relationships between exudate TOC and soil microbial biomass, soil enzymes (NAGase and phenol oxidase) and net nitrogen transformation rates following Phillips et al. (2011) and Yin et al. (2013).

(4) The composition of nutrients uptaken by trees will be determined through nutrient sap flow sampling and analysis on a San^{++} Continuous Flow Analyser (Alexou and Peuke, 2012).

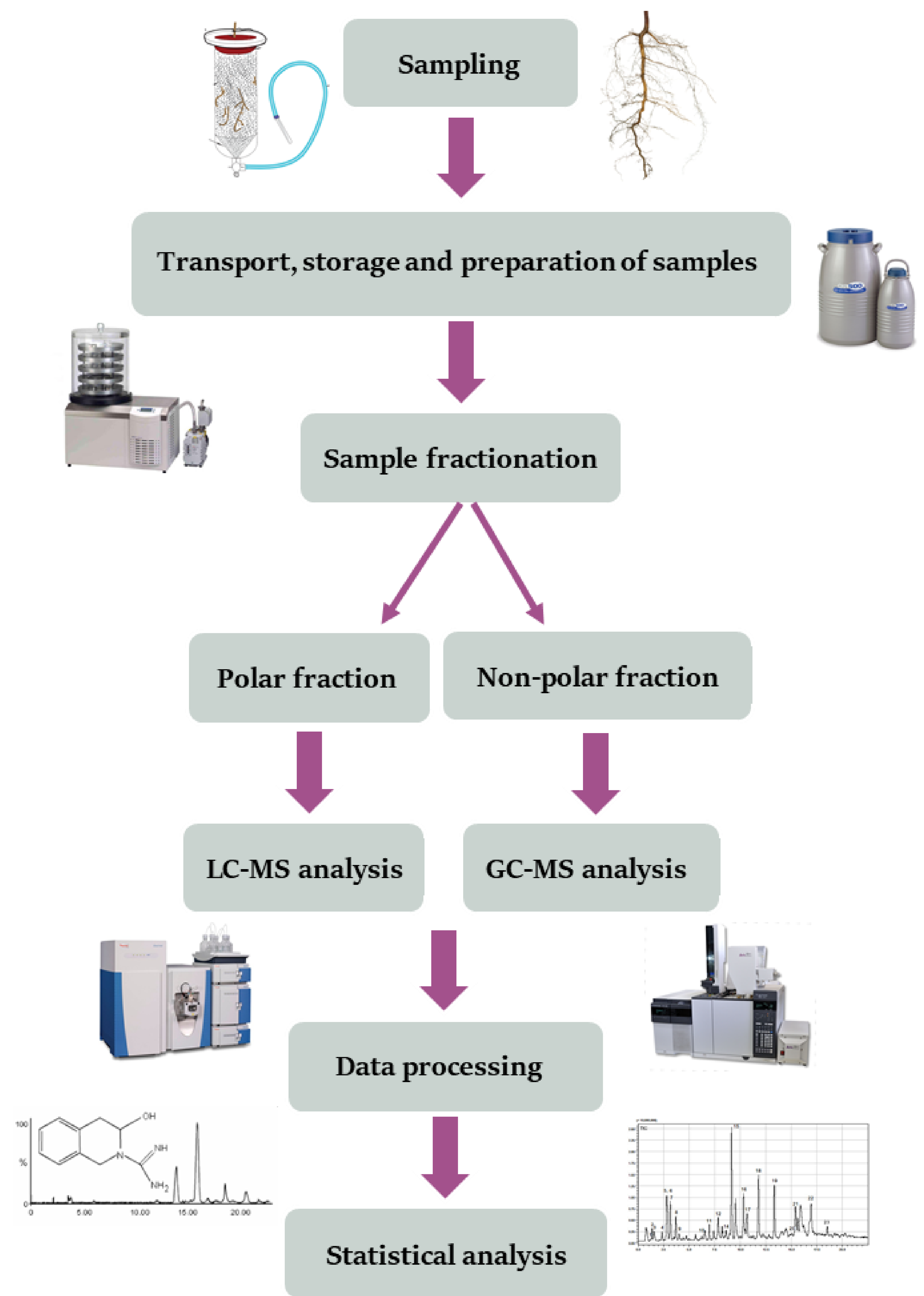

Figure 3. Simplified diagram of the methodology for determination of the composition of root exudation. Adapted from Oravec et al. (2018).

Expected results

- Exudation rates (TOC) will increase in the plots with elevated CO_2 (Fig. 4).
- The composition of exudates will differ between plots with elevated and ambient CO_2.
- Differing root exudation patterns between treatments will increase tree nutrient availability through stimulation of microbial activity and faster turnover of nutrients.
- This, in turn, will affect the composition of nutrients uptaken by trees.

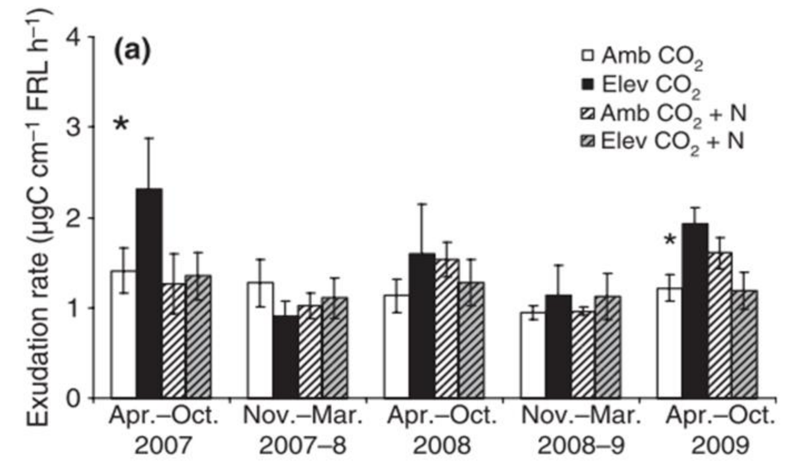

Figure 4. Bar plot showing seasonal differences in exudation rates (TOC) between treatments from Phillips et al. (2011).

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