NITROGEN TRANSFORMATION MEDIATED BY ARTIFICIAL ROOT EXUDATES DERIVED FROM YOUNG ALDER AND ENGLISH OAK TREES

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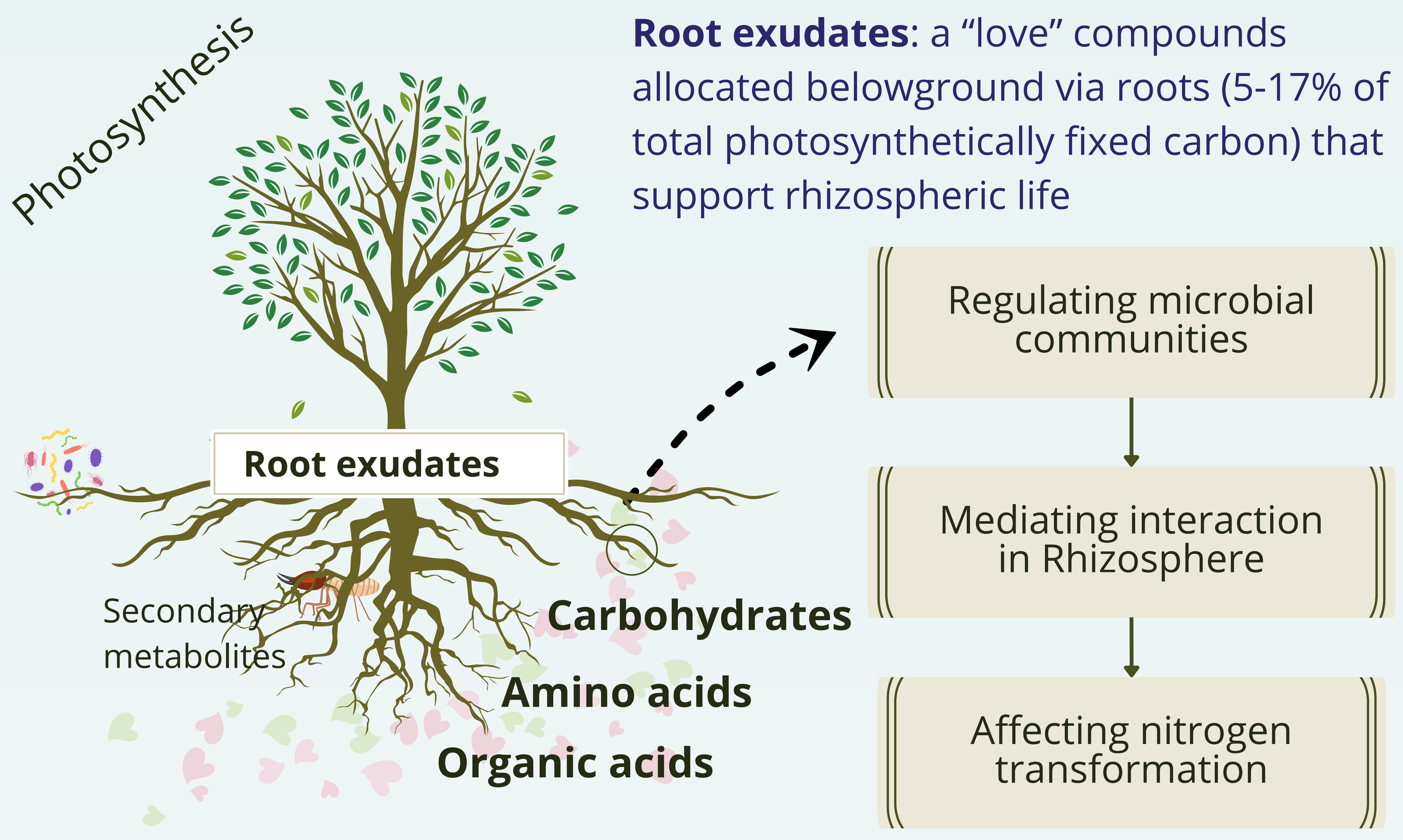
Introduction

Root exudates: a "love" compounds allocated belowground via roots (5-17% of total photosynthetically fixed carbon) that support rhizospheric life

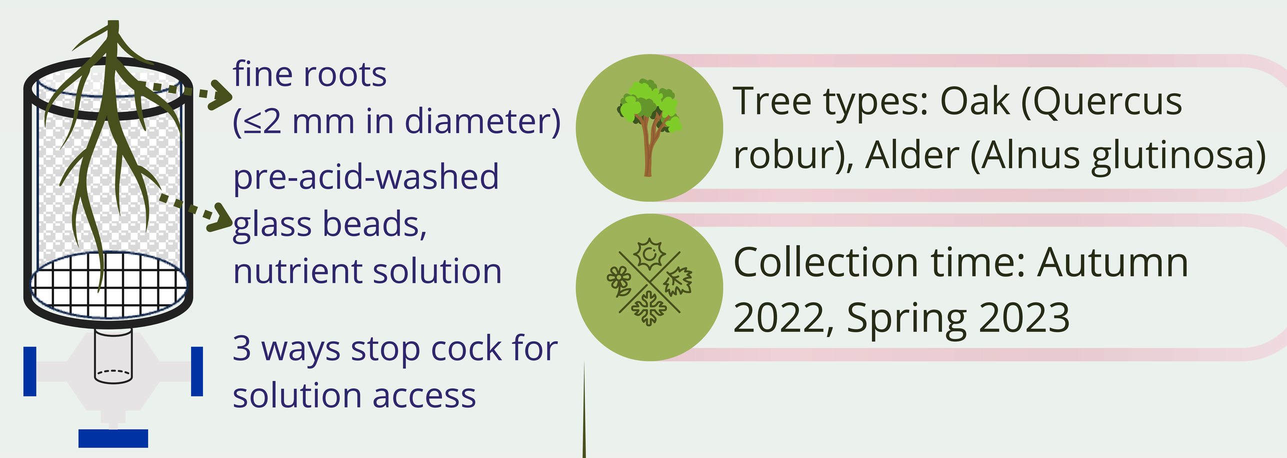


Aim: To investigate how root exudates from English oak (Quercus robur) influence nitrogen cycling in rhizosphere soils compared to soils under alder (Alnus glutinosa).

Hypothesis: Oak root exudates would prime faster N transformation, given that alder tree roots host nodules for biological nitrogen fixation and thus will not invest exudate C in nitrogen acquisition.

Method

1.Root exudate collection (Philip, 2008)



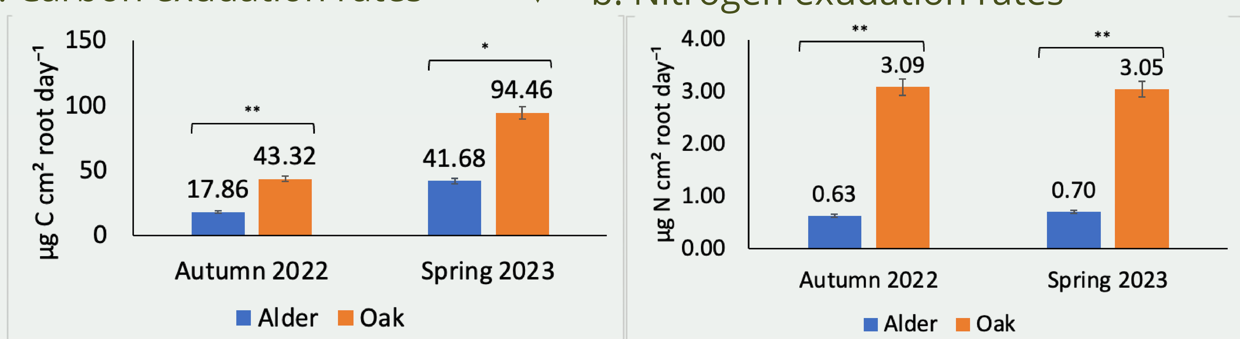


Fig. 1a and 1b. Carbon and nitrogen exudation rates based on root surface area. Oak exhibited higher exudation rates of both carbon and nitrogen than alder, but with a lower C:N ratio.

2. Lab incubation to study the root exudates on N mineralisation

- Soil was sampled from the top 15 cm of a four-year-old oak and alder monoculture plantation in Staffordshire, UK.
- Artificial root exudates were applied daily for 15 or 30 days to mimic natural exudation.

Table 1. Artificial root exudate composition derived from 6-month field exudation, replicated in a 1-month laboratory simulation.

	Control	Oak 1	Oak 2	Alder 1	Alder 2
Soil texture		Silt loam		Sandy loam	
Sugar conc (mM)	-	12.52	68.52	6.78	45.93
Sugar compounds	-	fructose, ribose, sucrose			
Org acid conc (mM)	-	20.57	112.58	11.14	37.73
Org acid compounds	-	citric, malic, fumaric			
Amino acid conc (mM)	-	5.70	28.15	1.16	6.46
Amino acid compounds	-	valine, serine, glutamine			
C added each time (ug C/g soil)	-	186.68	814.13	76.97	359.23
N added each time (ug N/g soil)	-	13.32	26.29	2.71	6.03
C:N	-	14.02	30.97	28.35	59.54

- At the end of each period, soils were retrieved from the incubation chambers and amended with a ^{15}N tracer to quantify gross nitrogen mineralization.
- Microbial activity, nitrogen mineralization, and nitrogen availability were subsequently assessed.

Result 1. Root exudation stimulates microbial activities

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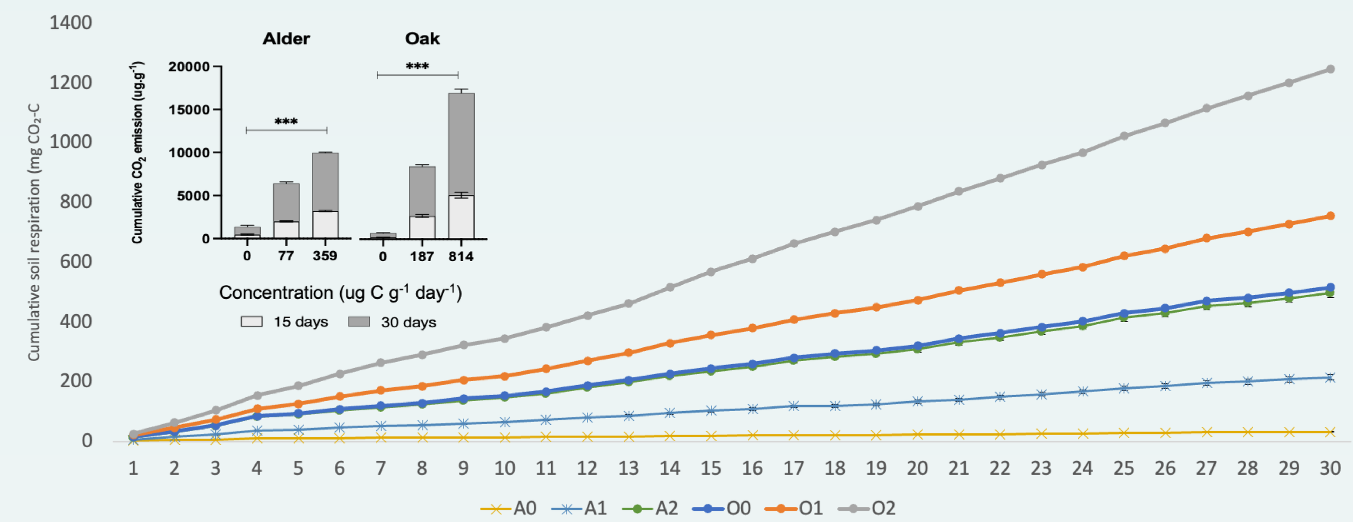


Fig. 2: Cumulative soil respiration

- Enhanced root exudate levels significantly (p<0.001) promoted higher cumulative soil carbon emissions. Cumulative soil respiration had a positive correlation to MBC (alder: r^2 = 0.89; oak: r^2 = 0.75).
- The microbial metabolic quotient (qCO_2) significantly increased (p<0.05) in response to carbon enrichment through exudation

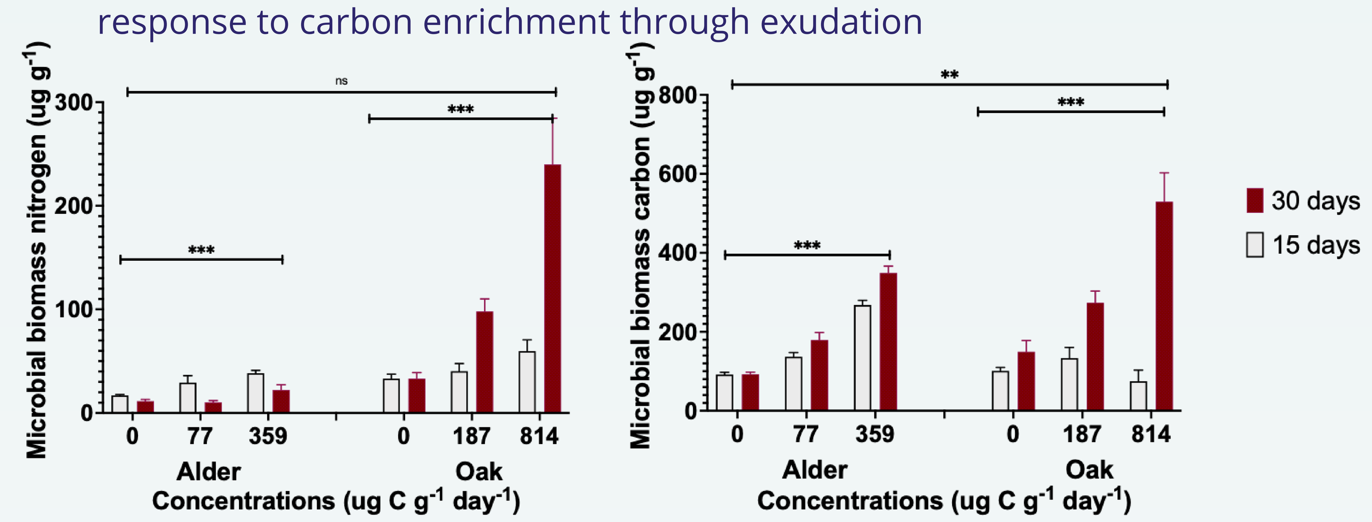


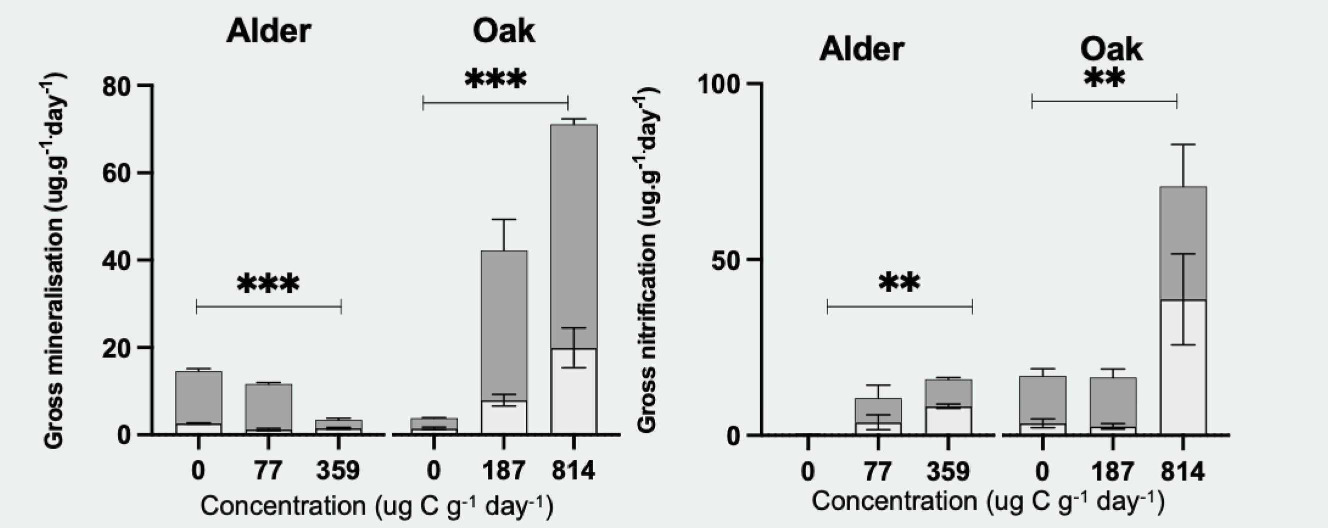
Fig. 3: Microbial biomass carbon and nitrogen

After 30 days of incubation, root exudate addition increased microbial biomass carbon and nitrogen relative to the control, accompanied by elevated levels of dissolved organic carbon and nitrogen.

Result 2. N transformation are affected by root exudation

2.N transformation are significantly affected by root exudation

a. Gross mineralisation and nitrification



b. Net mineralisation and nitrification

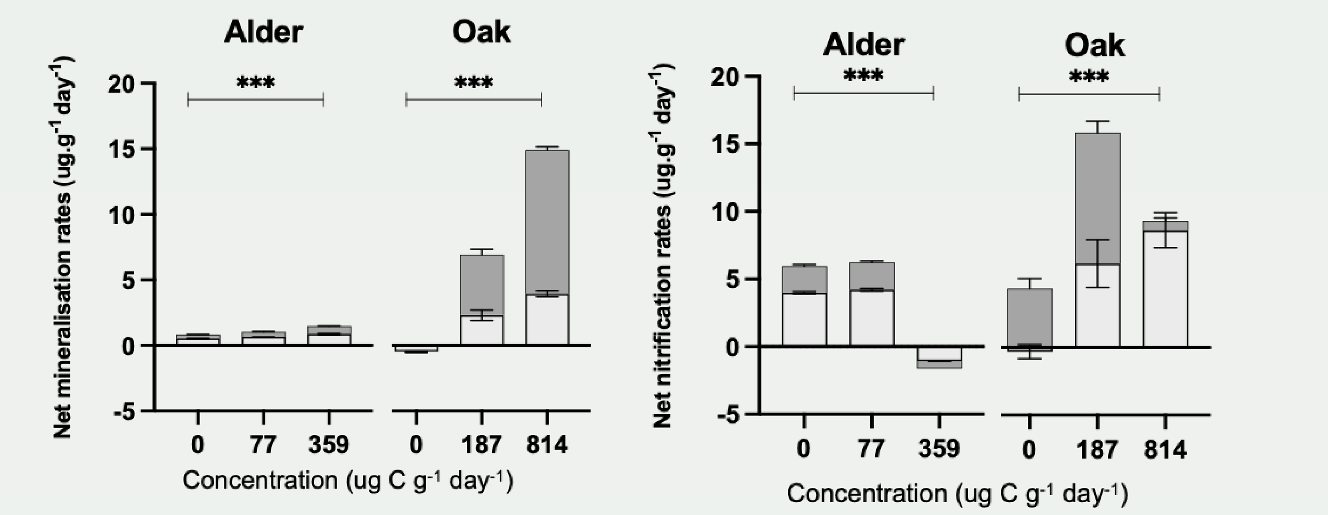


Fig. 4: (a) Gross mineralisation and nitrification and (b) Net mineralisation and nitrification

- Root carbon inputs influenced both mineralization and nitrification.
- High exudates boosted oak's gross mineralization 20-fold but cut alder's by 5-fold.
- Net mineralization rose with exudate concentration in both species
- Oak root exudates exhibited higher responses across gross mineralization (lnRR=3.08), net mineralization (lnRR=2.50), and gross nitrification (lnRR=1.57) compared to alder.

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Take home messages

- Oak exudates had higher C and N inputs but a lower C:N ratio, boosting nitrogen mineralization.
- Exudates enhanced microbial biomass N, increasing NH_4^+ and NO_3^- availability.
- Soil N pools grew over time, showing sustained exudate effects.
- Stronger N cycling in oak highlights species-specific impacts on rhizosphere nutrient dynamics.

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