The Exeter Soil Carbon Sequestration Lab (ExSEQ)

Advancing Quantification of Soil Carbon Dynamics and Climate Mitigation Potential

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Introduction

- Soil carbon changes are small relative to large background stocks[1,2], occur slowly, and may be offset by N_2O and CH_4 emissions[3,4].
- Most land-based mitigation project cannot quantify these processes reliably, creating uncertainty in climate benefit estimates.

ExSEQ enables high-resolution monitoring of soil carbon dynamics and greenhouse gas fluxes, reducing this uncertainty.

ExSEQ
Exeter Soil Carbon Sequestration Lab
MEASURE • UNDERSTAND • MITIGATE

What ExSEQ measures

Greenhouse gas fluxes

- Continuous measurement of CO_2, CH_4, and N_2O fluxes (Figs. 5, 6).
- High temporal resolution captures dynamics often missed by conventional approaches, including short-lived N_2O emission spikes following fertilizer addition (Fig. 5a).
- Full greenhouse gas budgets.

Carbon tracking

- The strong isotopic signal allows tracing of plant-derived carbon into soils and quantification of new soil organic matter formation, even when it contributes less than 0.5% of total SOM[5].

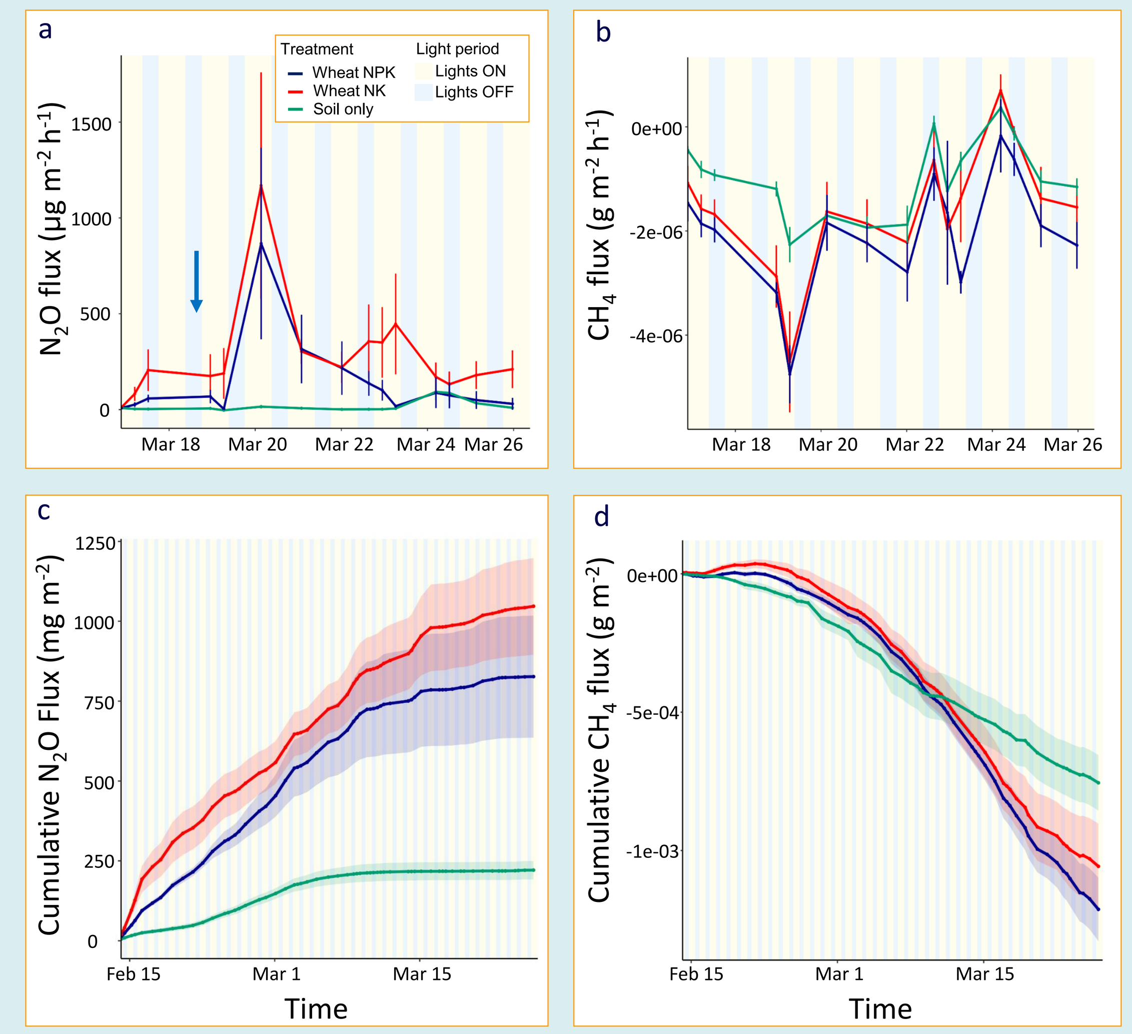

Fig. 5 N_2O and CH_4 emissions from wheat-grown soils under different fertilizer treatments. Hourly (a,b) and cumulative fluxes (c,d) are shown (mean ± SE, n=6). Blue arrow in panel **a** denotes fertilizer addition.

Source partitioning

- Separates root- and SOM-derived CO_2 fluxes (Fig. 6).
- Reveals patterns difficult to detect otherwise. For instance, root-derived CO_2 increases gradually as the growing season progresses (Fig. 6b).

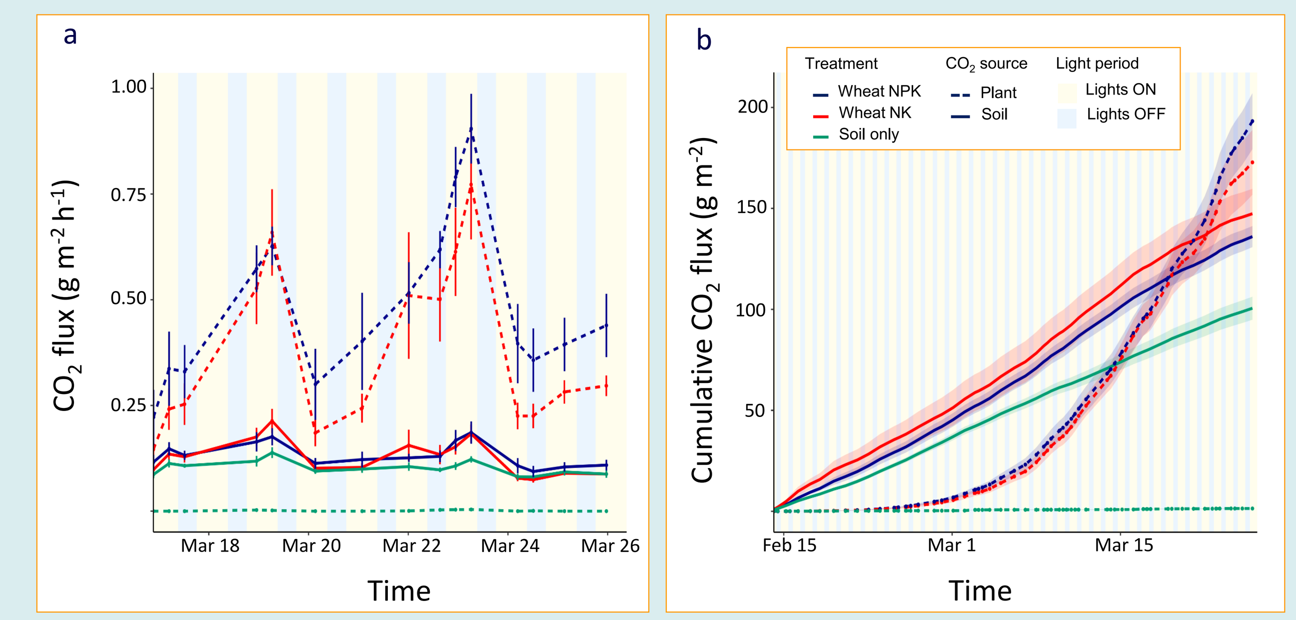

Fig. 6 Root respiration and SOM-derived CO_2 under different fertilizer treatments. Hourly (a) and cumulative fluxes (b) are shown (mean ± SE, n=6).

How ExSEQ works

- Two large growth chambers (Fig. 1) with controlled temperature, light, CO_2, and humidity enable plant growth under realistic conditions.
- Pasture species and arable crops can be grown through their full life cycles under continuous $^{13}CO_2$-labelling (~500‰; Figs. 2-4).
- Closed system design allows flux measurements without opening chambers, preventing isotopic dilution.
- Up to 104 experimental units can be monitored in tandem.
- High-frequency sampling infrastructure supports hourly to daily gas flux measurements.

Fig. 1 ExSEQ growth chambers, equipped for continuous ^{13}C labelling and gas flux measurements

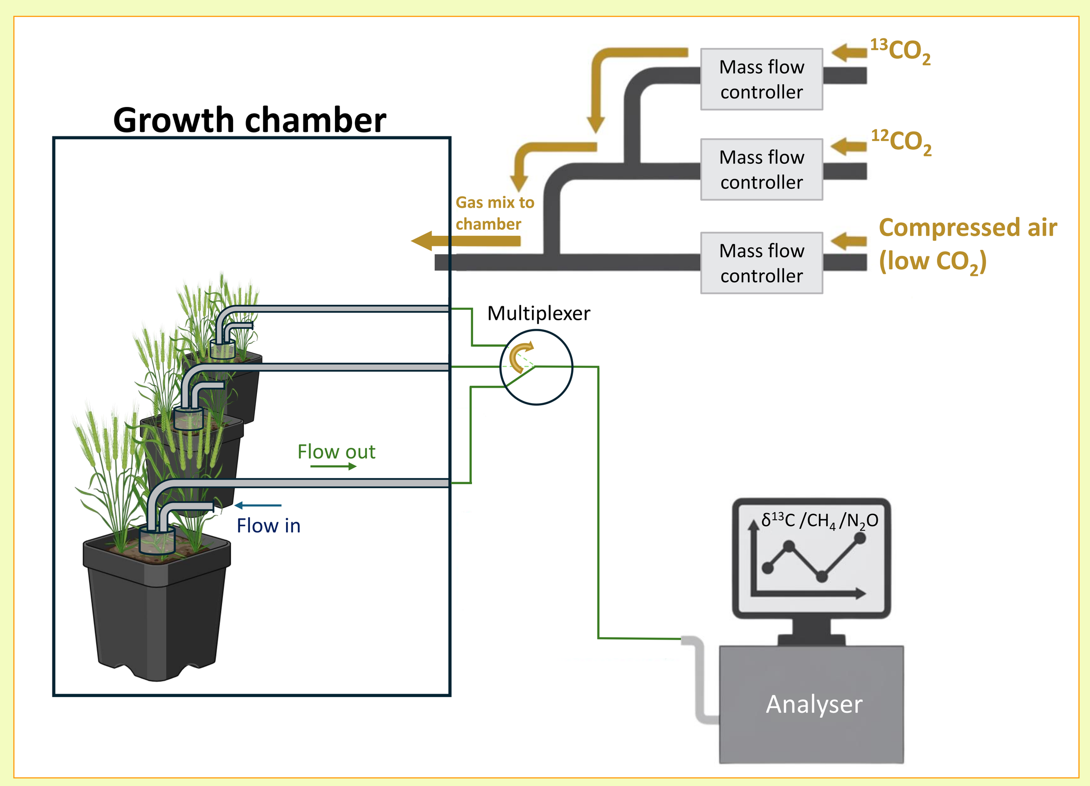

Fig. 2 Controlled gas mixing and sampling system in the **ExSEQ** growth chambers. A mixture of gases ($^{13}CO_2$, $^{12}CO_2$, air) is delivered to each chamber. A pull-through system continuously draws headspace air from each unit, and a multiplexer sequentially routes the sampled air from each unit to the gas analyser.

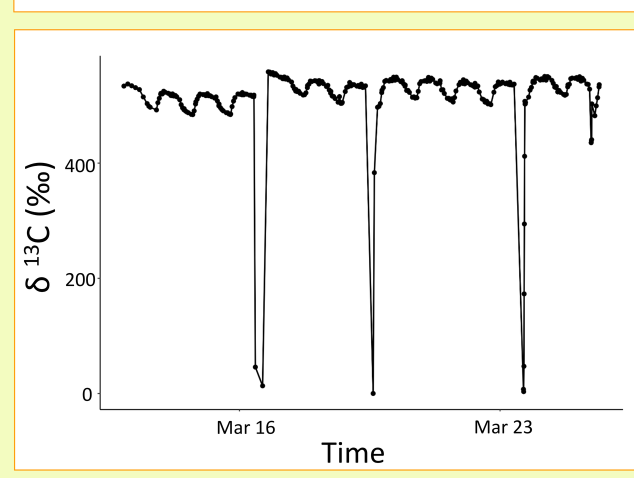

Fig. 3 Stable $\delta^{13}C$ of background air CO_2 in the growth chambers. Dips represent opening of chamber for watering.

Fig. 4 Plant growth trials (wheat and grassland species) have been conducted in both growth chambers.

Collaborate with us

- Evaluate impacts of fertilisers, soil amendments (e.g. enhanced rock weathering, biochar, and biostimulants), and management practices (e.g. tillage intensity, pasture diversity, and grazing strategies).
- Flexible deployment across a wide range of land management systems.
- We support academia-industry collaboration, accelerating innovation and real-world application.

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