Effect of elevated CO_2 and soil nitrogen availability on plant C allocation and soil C turnover from a whole-plant mesocosm experiment

Hye In Yang[*,1], Marion Schrumpf[1], Sönke Zaehle[1]

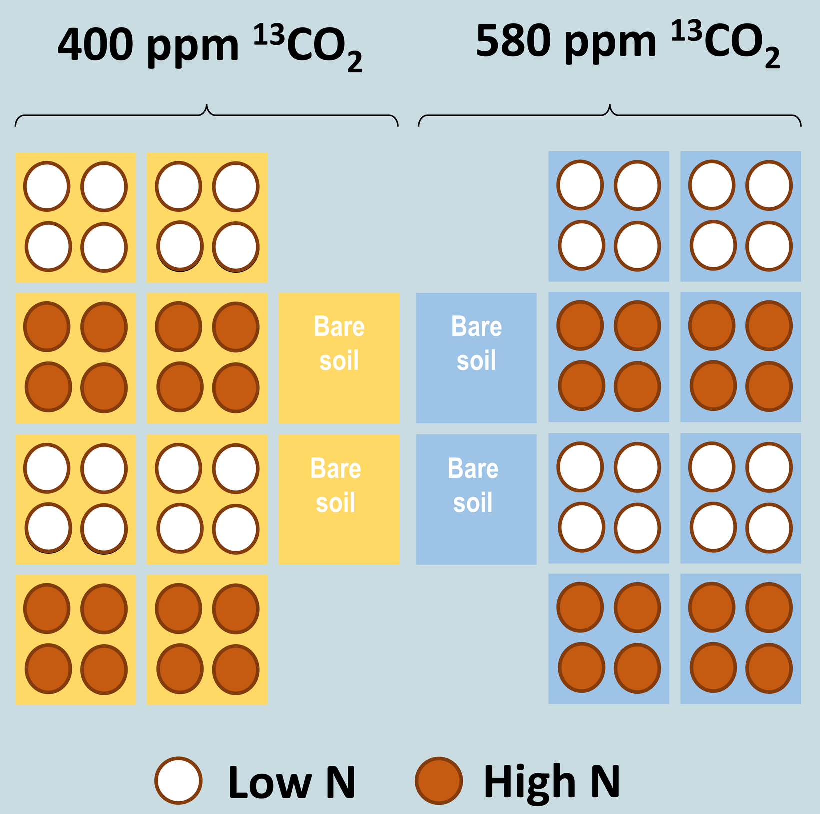
[1]Max Planck Institute for Biogeochemistry, Jena, Germany *Email: hyang@bgc-jena.mpg.de

INTRODUCTION

- Elevated CO_2 concentration in the atmosphere can increases plant growth as well as belowground allocation of photosynthetically fixed carbon.
- Carbon-rich root exudates secreted from plant roots (rhizodeposition) are used by soil microbes and potentially stimulate soil C turnover through positive priming.
- This priming effect is influenced by soil nutrient status, especially N, which is the most limiting nutrient. Rhizodeposition has been identified as a nutrient mining mechanism under limiting conditions.
- However, increased soil N suppresses organic C mineralization, resulting in a contrasting effect to elevated CO_2 and increased rhizodeposition on C turnover.

Research aim: to conduct a tree mesocosm experiment using different combinations of CO_2 and N levels to investigate how plant response to co-elevated levels of CO_2 and available N change in terms of growth and rhizodeposition, and consequently affect microbe-mediated C turnover

METHOD



Greenhouse mesocosm experiment

- 64 hornbeam trees (Carpinus betulus) grown in sealed mesocosms
- ^{13}C labeled CO_2 (100 ‰)
  - Ambient at 400 ppm (aCO_2)
  - Elevated at 580 ppm (eCO_2)
- ^{15}N labelled NH_4NO_3 application
  - Low N at 0.6 g N m^{-2}
  - High N at 5.4 g N m^{-2}

Monitoring during grwoth

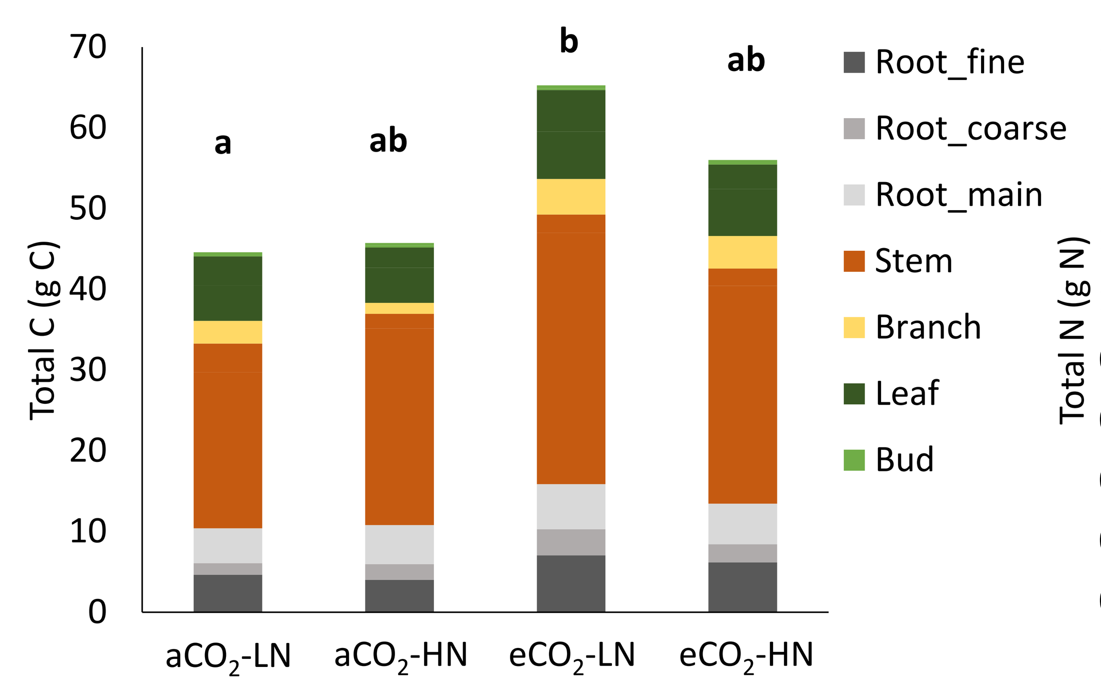
- Aboveground CO_2 and belowground CO_2 concentration and isotopic signature were continuously measured

Sampling and analysis

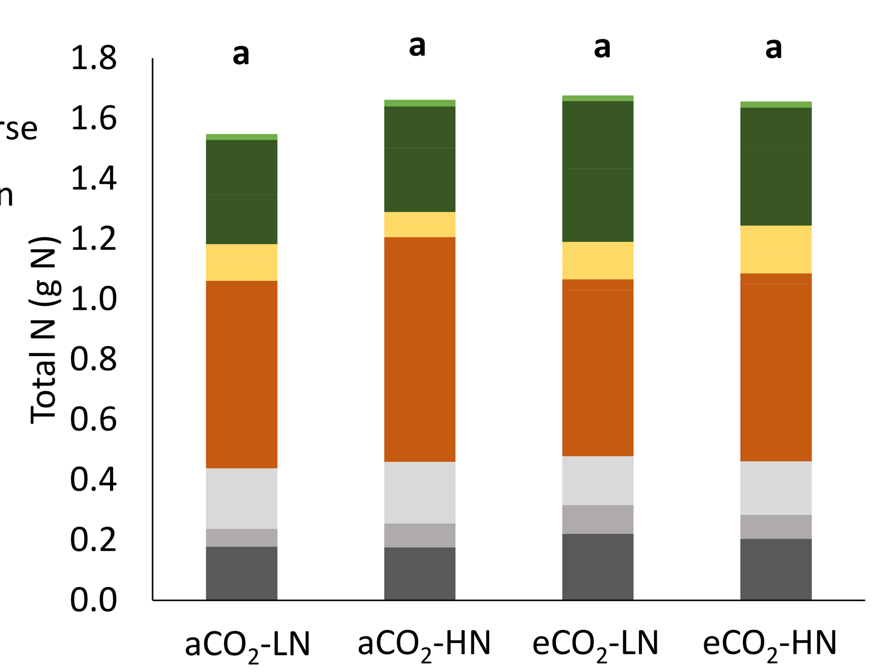
- Trees were destructively harvested at the end of growing season
- Trees were divided into different aboveground and belowground parts, cut into small pieces, dried and ground for measurement
  - Buds, leaves, branch, stem and main, coarse and fine roots
- Soils were separated into bulk soil and rhizosphere soil
- Soil microbial carbon, extracellular enzyme activities were measured

RESULTS

Total C in tree tissues at harvest

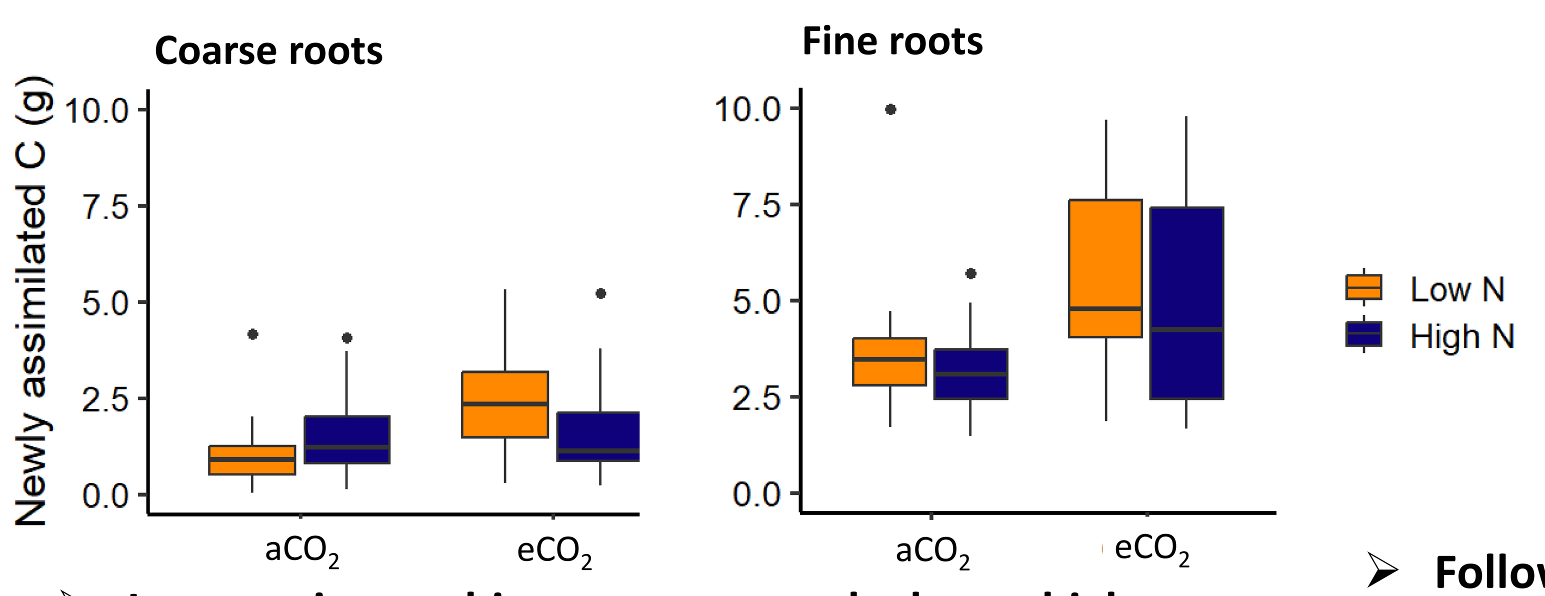


Total N in tree tissues at harvest



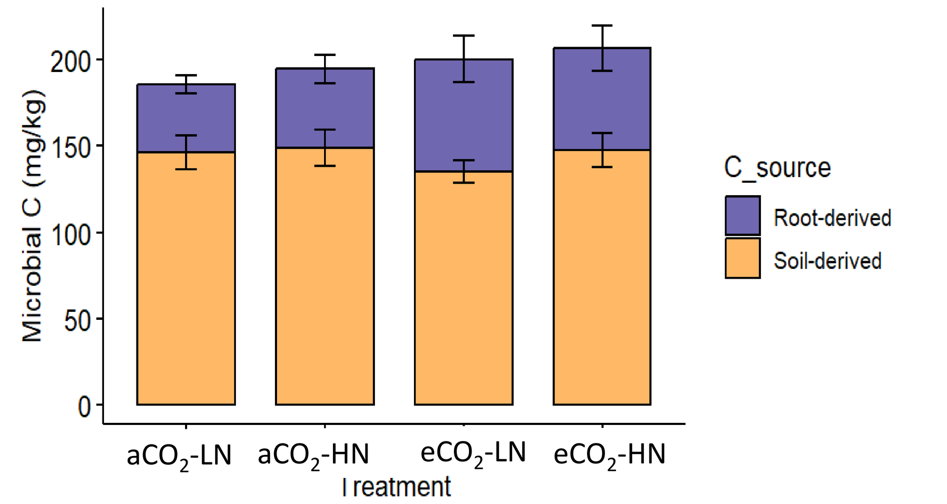
- Biomass C increased under eCO_2 but N effect was not observed, which suggested that trees were not limited by N
- However, N concentration in tree tissues decreased under eCO_2 even with high N, while biomass increased, which resulted in no difference in total N across treatments

New C assimilated from $^{13}CO_2$



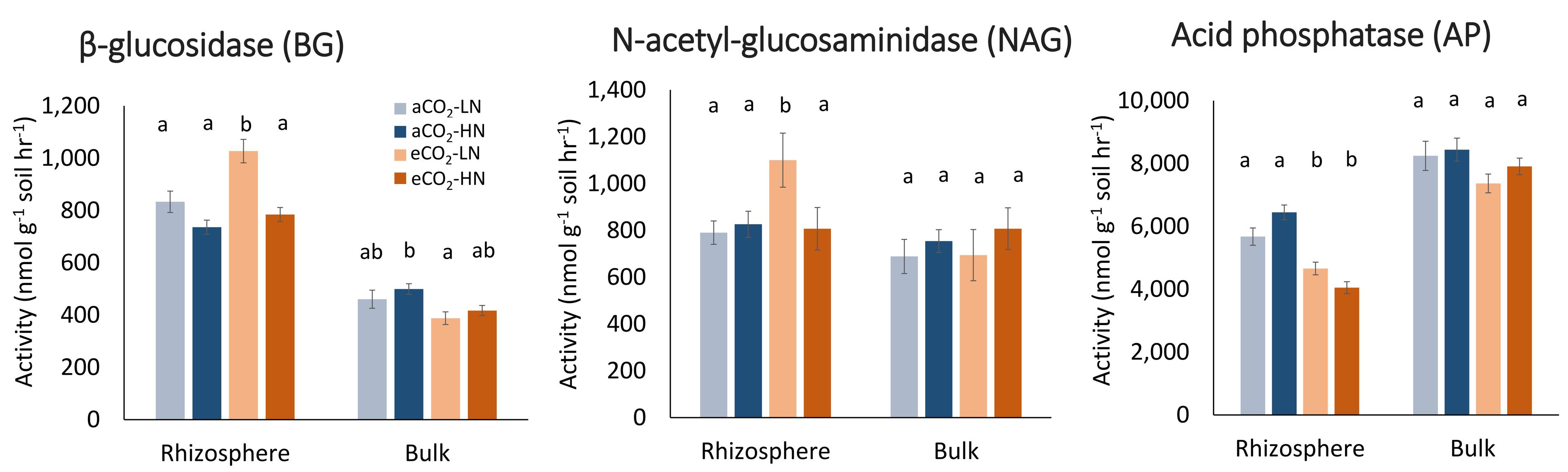
- Increase in root biomass was mostly due to higher allocation of newly photosynthesized C to coarse roots ($p=0.04$) and fine roots($p=0.01$) under eCO_2

Microbial C derived from soils and roots



- Following increased C allocation belowground, microbial uptake of root-derived C also increased under eCO_2. However, this did not lead to a significant change in total microbial biomass C. Nitrogen effect was not observed.

Extracellular enzyme activities in soils at harvest



- BG activity increased in rhizosphere soils under eCO_2-LN treatment, indicating possible microbial N mining
- AP activity in rhizosphere soils was lower under eCO_2 suggesting P was not a limiting factor for plant or microbial growth
- Enzyme activities in rhizosphere soils were directly influenced by roots but the effect did not translate into changes in the bulk soil enzyme activities

SUMMARY

- Elevated CO_2 increased belowground C allocation of trees and subsequent use of root-derived C by microbes, but did not lead to changes in total microbial biomass or soil organic C at the end of the growing season
- Increasing available N did not significantly affect the C allocation pattern of trees. However, an increase in extracellular enzyme activities, especially C and N hydrolyzing enzymes, suggests possible nutrient mining under eCO_2 at low N, but not at high N.
- Further analysis of mesocosm CO_2 flux and isotopic signature data will enable a deeper understanding of tree C uptake and soil C turnover under the imposed experimental conditions.