Soil nutrients in a mature natural mixed forest exposed to elevated CO_2

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Introduction

Forests may mitigate the carbon dioxide (CO_2) enrichment of the Earth's atmosphere through an increasing productivity under elevated CO_2. Direct growth stimulation by elevated CO_2 has been experimentally confirmed for potted seedlings and juvenile forests, but not yet for mature trees. Since the C and nutrient cycles – especially nitrogen (N) – are closely associated, the CO_2 effect on nutrient cycling is of key importance for the C sequestration. As the availability of nutrients will probably not increase proportionally with CO_2, nutrient limitation may, in turn, reduce the plant response to elevated CO_2. In an earlier experiment (Brunold et al. 2001) in model ecosystems with young spruce and beech in open-top chambers, the nitrate concentration of the soil solution was strongly reduced after 4 years exposure to elevated CO_2 (Hagedorn et al. 2000 and 2002). This phenomenon was mainly interpreted as an immobilization of nitrogen in the soil through stimulated microbial activity.

In this experiment we monitor continuously the nutritional status in the soil under control and CO_2-fumigated trees in an undisturbed 120 years old mixed forest. If these trees will really respond long-term to the additional CO_2, this may show up not only in the crowns but also in the soil. Sampling and analysis of soil solutions is a non-destructive and easily practicable method to estimate the plant-available nutrients and other dissolved compounds in the soil and may deliver suitable indicators for environmental changes of the ecosystem.

Material and Methods

- CO_2 enrichment (500 µmol mol^{-1}) in a mature forest (Swiss Canopy Crane project, Fig.1) (Pepin and Körner 2002)
- ceramic suction cups at depths of 5 and 15 cm along three transects (Fig. 2)
- resin bags
- $\delta^{13}C$ of roots and acidified and lyophilized soil solutions

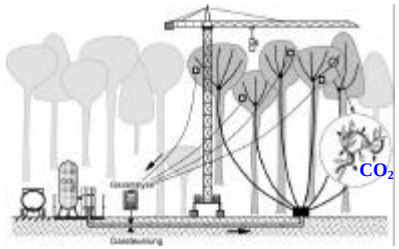

Fig. 1: New canopy free air CO_2 enrichment (web-FACE) at the Swiss Canopy Crane (SCC) site in Hofstetten, Switzerland. Design and set-up Prof. Ch. Körner, Botanical Institute University of Basel.

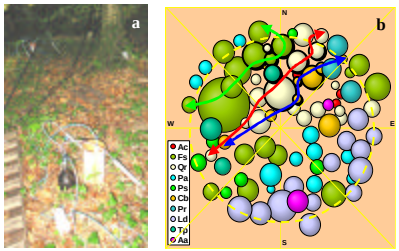

Fig. 2 : a) System of suction cups for the collection of soil solution at different depths. b) Canopy map of the SCC site and transects for collection of soil solution under beech (green), oak (red) and hornbeam (blue). Tree crowns in bold and shadowed circles are exposed to elevated CO_2.

Results

- seasonal pattern of the nitrate concentration in the soil solution, mostly with high concentration in winter
- indication of enhanced nitrate availability under *Fagus* and *Quercus*, but not under *Carpinus* trees exposed to elevated CO_2 (Fig. 3 and 4)
- no clear influence of tree species, season or treatment on the ammonium concentrations of the soil solution.
- slight decline of $\delta^{13}C$ in fine roots of trees exposed to elevated CO_2, however, no difference in the isotopic abundance of the soil solution under treated and untreated trees at the end of the first growing season (Fig. 5)

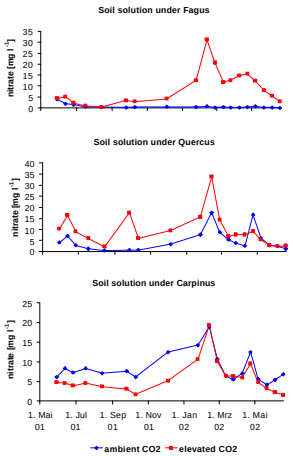

Fig. 3: Nitrate concentration of soil solutions at 15 cm soil depth under trees along the transects during the first year of exposure to elevated CO_2 (means of 4-5 samples per date, species and treatment)

Conclusion

- **the soil is probably not yet much influenced by the CO_2 enrichment of the tree crowns, and it is too early to estimate whether the observed nutrient effects are due to the CO_2-treatment or to the natural variability of the soil**

References

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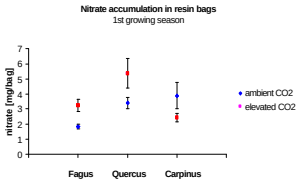

Fig. 4: Nitrate accumulation in resin bags at 0-5 cm soil depth during the first growing season (May-Oct.) of exposure to elevated CO_2 (means and S.E. of 12-15 bags)

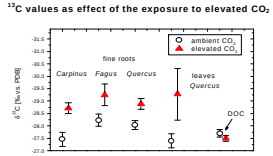

Fig. 5: The $d^{13}C$ values in fine roots, leaves and dissolved organic carbons (DOC) in the soil solution, October 2001.