Geophysical Research Abstracts
Vol. 12, EGU2010-6769, 2010
EGU General Assembly 2010

Elevated atmospheric CO2 increases microbial growth rates and enzymes activity in soil

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Increasing the belowground translocation of assimilated carbon by plants grown under elevated CO2 can cause a shift in the structure and activity of the microbial community responsible for the turnover of organic matter in soil. We investigated the long-term effect of elevated CO2 in the atmosphere on microbial biomass and specific growth rates in root-free and rhizosphere soil. The experiments were conducted under two free air carbon dioxide enrichment (FACE) systems: in Hohenheim and Braunschweig, as well as in the intensively managed forest mesocosm of the Biosphere 2 Laboratory (B2L) in Oracle, AZ. Specific microbial growth rates (μ) were determined using the substrate-induced respiration response after glucose and/or yeast extract addition to the soil. We evaluated the effect of elevated CO2 on b-glucosidase, chitinase, phosphatase, and sulfatase to estimate the potential enzyme activity after soil amendment with glucose and nutrients.

For B2L and both FACE systems, up to 58% higher μ were observed under elevated vs. ambient CO2, depending on site, plant species and N fertilization. The μ-values increased linearly with atmospheric CO2 concentration at all three sites. The effect of elevated CO2 on rhizosphere microorganisms was plant dependent and increased for: Brassica napus=Triticum aestivum<Beta vulgaris<Populus deltoides. N deficiency affected microbial growth rates directly (N limitation) and indirectly (changing the quantity of fine roots). So, 50% decrease in N fertilization caused the overall increase or decrease of microbial growth rates depending on plant species. The μ-value increase was lower for microorganisms growing on yeast extract then for those growing on glucose, i.e. the effect of elevated CO2 was smoothed on rich vs. simple substrate. So, the r/K strategies ratio can be better revealed by studying growth on simple (glucose) than on rich substrate mixtures (yeast extract). After adding glucose, enzyme activities under elevated CO2 were 1.2–1.9-fold higher than under ambient CO2. This indicates the increased activity of microorganisms, which leads to accelerated C turnover in soil under elevated CO2.

Our results clearly showed that the functional characteristics of the soil microbial community (i.e. specific growth rates and enzymes activity) rather than total microbial biomass amount are sensitive to increased atmospheric CO2. We conclude that the more abundant available organics released by roots at elevated CO2 altered the ecological strategy of the soil microbial community specifically a shift to a higher contribution of fast-growing r-selected species was observed. These changes in functional structure of the soil microbial community may counterbalance higher C input into the soil under elevated atmospheric CO2 concentration.