SUBSTRATE INDUCED GROWTH RESPONSE OF SOIL AND RHIZOSPHERE MICROBIAL COMMUNITIES UNDER ELEVATED CO_2

S.A. Blagodatsky[1], E.V. Blagodatskaya[1], T.-H. Anderson[2], E.G. Demyanova[1], V.N. Kudeyarov[1], and H.-J. Weigel[2]

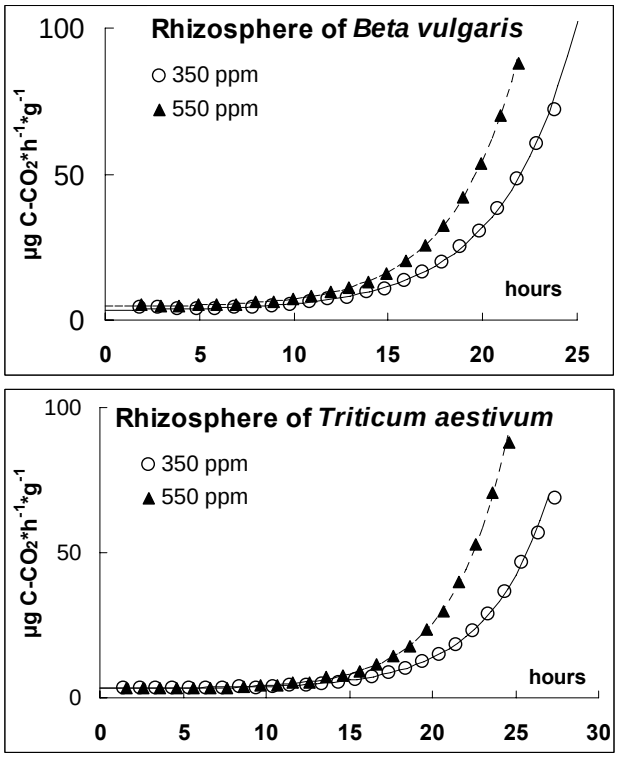
[1]*Institute of Physicochemical and Biological Problems in Soil Science, Russian Academy of Sciences, 142290 Pushchino, Russia; sblag@mail.ru*

[2]*Institute of Agroecology (FAL), Bundesallee 50, 38116 Braunschweig, Germany; heidi.anderson@fal.de*

ABSTRACT

The maximal specific growth rate of microorganisms from rhizospheres of *Populus deltoides* grown under normal CO_2 concentration in the atmosphere (400 ppm) was lower compared to the assessments made for plots under elevated CO_2 (800 and 1200 ppm). A similar conclusion was made for microbial communities from soil under winter wheat and sugar beets grown under 370 and 550 ppm CO_2 in the atmosphere. Three to four years fumigation of field plots with elevated CO_2 has been shown to result in the formation of rhizosphere microbial communities characterized by faster specific growth rates as compared to microbial community under control plants.

The scenario of CO_2 accumulation in the atmosphere depends to a large extent on the potential of terrestrial ecosystems to regulate the CO_2 level. In spite of the large efforts of soil scientists, it is still unclear how the soil carbon cycle and its key component – microbial activity - will be modified in an "elevated CO_2 world". The aim of our study was to investigate the effect of elevated CO_2 in the atmosphere on soil microbial biomass and kinetic characteristics of microbial respiratory response. Soils from the intensive agroforestry biome "Biosphere 2," in Oracle, Arizona, USA [*Torbert and Johnson*, 2001] and from FACE experiments, Braunschweig, Germany [*Weigel and Dämmgen*, 2000] have been studied.



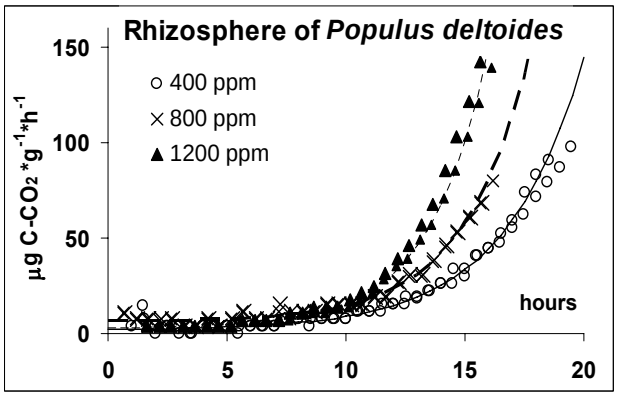


Fig.1 Kinetics of substrate induced respiration for rhizosphere soil under three plant species grown at different levels of atmospheric CO_2 concentration. Simulated data are shown as lines (Eq. 1) and measured data as symbols

$$v(t) = A + B * \exp(\mu_m * t), \quad (1)$$

where A = initial rate of uncoupled (non-growth) respiration, B = initial rate of coupled (growth) respiration, μ_m = maximum specific growth rate, t = time.

The dynamics of the CO_2 emission rate were recorded after soil amendment with glucose and mineral salts using an automated continuous-flow system with an infrared gas analyzer. Specific growth rates of soil microorganisms were determined using the substrate induced growth response expressed as an increase of soil respiration rates. Total and active microbial biomasses were estimated by SIR and kinetic methods [*Blagodatsky et al.,* 2000].

The respiration curves were markedly different under elevated and ambient CO_2 for all variants of soil or rhizospheres (Fig. 1) taken from plots with different plants grown either in a closed system (poplar) or under field conditions (sugar beets and winter wheat). The data obtained were described by a simple model (Eq. 1), and optimised parameters (Table 1) showed that:

- Specific growth rates (μ) of soil microorganisms were faster for plots with elevated CO_2 concentrations;
- Size of total microbial biomass and fraction of growing microorganisms did not show a unique response to elevated CO_2 for three cases studied;
- Three-way ANOVA showed that among three factors studied (CO_2 concentration in atmosphere, distance from roots and N application rate), the CO_2 level has a highest influence on μ.

Table 1. Effect of elevated atmospheric CO_2 concentration on specific growth rate, activity status and biomass of microorganisms in rhizospheres of three different plant species.

Crop	CO_2, in atmosphere, ppm	Specific growth rate on glucose, μ_{max} (h^{-1})± SE	Microbial biomass (SIR) (μg C*g^{-1})±SE	Fraction of growing microorganisms %
Poplar	400	0.301 ±0.007	243.5 ±1.2	1.05
	800	0.39 ±0.04	244.4 ±1.0	0.34
	1200	0.47 ±0.06	173.7 ±0.5	0.35
Sugar beet	350	0.246 ±0.003	297 ±1	0.71
	550	0.284 ±0.001	366 ±10	0.39
Winter wheat	350	0.255 ±0.007	240 ±27.5	0.22
	550	0.297 ±0.005	250 ±20.2	0.20

The observed increases in microbial specific growth rates are probably connected to the higher input of root exudates from plants grown under elevated CO_2. Microbial communities adapted to the higher level of carbonaceous substrates and species with faster growth rates (r-strategists) have an advantage under these conditions. The hypothesis of a causal link between the increase of atmosphere CO_2 concentration and acceleration of microbial biomass turnover in rhizospheres has been confirmed by our results.

ACKNOWLEDGMENTS

This research was supported by the BMVEL, DAAD and Russian Foundation for Basic Research (Project No 02-04-49843).

REFERENCES

Torbert, H.A. and H.B. Johnson (2001), Soil of the Intensive Agriculture Biome of Biosphere 2, *J. Soil and Water Cons., 56*, 4-11.

Weigel, H.-J. and U. Dämmgen (2000), The Braunschweig Carbon Project: atmospheric flux monitoring and Free Air Carbon Dioxide Enrichment (FACE). *J. Appl. Bot. 74*, 55-60

Blagodatsky, S.A., Heinemeyer O., Richter J. (2000), Estimating the active and total soil microbial biomass by kinetic respiration analysis. *Biol. Fertil. Soils 32,* 73-81.