EFFECT OF ELEVATED ATMOSPHERE CO_2 CONCENTRATION ON COTTONWOOD TREE GROWTH AND SOIL RESPIRATORY ACTIVITY

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ABSTRACT
The effect of three atmospheric CO_2 concentrations (ambient – 400 ppm, doubled – 800 ppm and tripled – 1200 ppm) has been studied (1) on the productivity of cottonwood tree (*Populus deltoides* Barr.), (2) on the activity of soil microbial biomass in rooting zone. It has been shown, that the total biomass of cottonwood trees increase under elevated CO_2 (2.61, 5.59 and 4 kg/tree for 400, 800 and 1200 ppm respectively). The highest production had the stem and coarse roots at 800 ppm (in 3 and 2 times higher as compared to ambient CO_2). Under 1200 ppm CO_2 we observed increased the roots biomass, but the biomass of leaves and branches was insignificant or didn't changed at all. The shoot/root ratio changed as following: 400 ppm – 1.8, 800 ppm – 2.3, 1200 ppm – 1.4. The rate of C-CO_2 flux from soil samples being incubated for 70 days increased in the row 1200>800>400 ppm CO_2, the average values of CO_2 emission were 2.76, 2.33, 2.02 mg $100g^{-1}\cdot day^{-1}$, respectively. The largest amount of C microbial biomass (C_{mb}) was in the variant with triple CO_2 concentration (75.1 mg $100g^{-1}$), and the lowest – under ambient concentration (53.7 mg $100g^{-1}$).

INTRODUCTION
Elevated atmosphere concentrations of CO_2 have effect on biological productivity of the terrestrial ecosystems (*Schimel*, 1995; *Melillo et al.,* 1996; *Hymus et al*., 2003; *Norby et al*., 2003; *Billings & Ziegler*, 2005; *Hu et al*., 2005). In turn, changes in productivity of plants and some of their physiological processes could change the structure and functioning of ecosystems and influence soil carbon balance (*Bazzaz, Sombroek*, 1996; *Ginkel et al.,* 2000). The elevated atmospheric concentrations of CO_2 are able to increase the amount of carbon in the rhizosphere as the result of intensive roots exudation. This, in turn, could affect the quantity and activity of fungi and bacteria. It should be given careful consideration to the study of soil organic matter (SOM) response to elevated CO_2, since to understand the mechanisms of SOM change under elevated atmospheric CO_2 could give more accurate results to predict trends of biochemical cycles in terrestrial ecosystems.

MATERIALS AND METHODS
The effect of three CO_2 concentrations in the atmosphere (ambient – 400 ppm, doubled – 800 ppm, tripled – 1200 ppm) has been studied on the productivity of cottonwood tree (*Populus deltoides* Barr.) in the Biosphere 2 Laboratory (Oracle, Arizona, USA). The estimation of the soil biological activity was carried out in the Institute of Physicochemical and Biological Problems in Soil Science RAS (Pushchino, Russia). The activities of the Biosphere 2 Laboratory are well documented elsewhere (*Torbert and Johnson*, 2001). The experimental plot consisted of three separated bioms where the corresponding concentrations were maintained. By the end of April 2002 there were installed three cylinders (110cm height and 150 cm in diameter) in each biom with thoroughly mixed soil (*Kudeyarov et al.,* 2002). The cottonwood trees planted in each cylinder were grown up to 18 months, then cut to estimate total plant biomass (aboveground + belowground). Soil samples from each cylinder were incubated under steady conditions (t=22-23°C, moisture–22-25 g/100 g soil) for 70 days. During this period the respiration rate was measured using gas chromatograph and the amount of microbial biomass carbon ($C_{m.b.}$) has been evaluated by approximation of the cumulative curve with the 1st-order kinetic equation.

RESULTS AND DISCUSSION
The data obtained in the experiment on the Biosphere 2 Laboratory showed the increasing of cottonwood net productivity under elevated concentrations of CO_2 in the atmosphere. The doubling of CO_2 gave rise to more intensive growth of plant biomass in comparison with triple concentration (Fig. 1). The total biomass of cottonwood showed the increasing under elevated CO_2: 2.61, 5.59 and 4 kg/tree for 400, 800 and 1200 ppm respectively. The strongest response had the stem and coarse roots: in 3 and 2 times higher in comparison with ambient concentration.

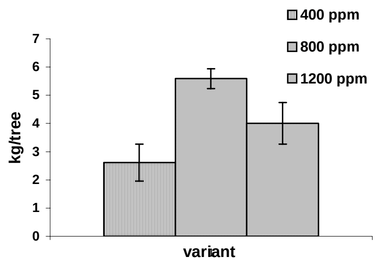

Fig.1. Plants' total dry weight under various concentrations of CO_2

The triple of [CO_2] has more influenced on the roots biomass, but the biomass of leaves and branches was insignificant or didn't change at all. The shoot/root ratio changed as following: 400 ppm – 1.8, 800 ppm – 2.3, 1200 ppm – 1.4. The elevation of carbon dioxide in the atmosphere resulted in growth of both above- and belowground biomass of plants. The rate of C-CO_2 flux increased in the row 1200>800>400 ppm CO_2, the average values of CO_2 emission were 2.76, 2.33, 2.02 mg $100g^{-1}\cdot day^{-1}$, respectively. The amount of microbial biomass has been increasing in soil under elevated concentrations of atmospheric carbon dioxide. The largest amount of C_{mb} was in the variant with triple CO_2 concentration and the lowest – under ambient concentration (Table 1). The experimental data shows the decreasing of microorganisms' metabolic activity while decomposing SOM under the atmospheric CO_2 elevation. Hence, the model experiment closed to natural ecosystems has shown that the elevated of [CO_2] in the atmosphere have a strong and complex influence on the terrestrial ecosystems. The doubling of CO_2 concentration leads to the growth of plants productivity when the amount of nutrients is sufficient. But the triple concentration of CO_2 exceeds necessary optimum for plants, affecting them to assimilate carbon ineffectively. This process is likely to increase root exudates. The consequence is, from the one hand, the activation of microorganisms, and from the other it might be a shift of species in the soil microbial pool joined with changed quality of plants residues.

Table 1. Influence of Different Concentrations of Atmospheric CO_2 on $C_{m.b.}$ in Soils and on the Metabolic Quotient

Atmospheric CO_2, ppm	$C_{m.b}$ mg $100g^{-1}$	k, $days^{-1}$	Metabolic quotient, C-CO_2/C-$C_{m.b.}$
400	53,7	0,866	2,35
800	67,9	0,666	2,43
1200	75,1	0,506	3,07

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