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Responses of soil CO_2 efflux to changes in plant CO_2 uptake and transpiration

János Balogh (1), Giulia de Luca (1), Ádám Mészáros (1), Júlia Trieber (1), Bernadett Gecse (1), Szilvia Fóti (2), Krisztina Pintér (2), Zoltán Nagy (1,2)

(1) Szent István University, Institute of Botany and Ecophysiology, Gödöllő, Hungary (balogh.janos@mkk.szie.hu), (2) MTA-SZIE Plant Ecology Research Group, Szent István University, Gödöllő, Hungary

Biotic drivers of soil respiration represent a significant supply-side (plant) control of the process. Those biotic drivers that integrate over longer time periods are useful in describing the phenological changes and physiological state of the vegetation, but they are not suitable to explain the diel variability of soil respiration. Two plant physiological processes, acting in opposite directions, could be relevant at diel timescale: (1) photosynthesis, and (2) transpiration. Firstly, it was recently found that photosynthesis has a time-lagged (a few hours) positive effect on the respiration of roots and root-associated microbes. This can be explainedby an increase in easily accessible non-structural hydrocarbon sources for the roots and root-associated organisms within this period. Secondly, it was found that the effect of transpiration could reduce root respiration due to CO_2 transport through the transpiration stream, and this effect is expected to be immediate.

Removing the effect of the abiotic drivers from the soil efflux signal could help to clarify the role of other driving variables. In the present study, we conducted manipulation measurements in lab environment to be able to detect the effects of the plant physiological variables (CO_2 uptake, transpiration) on soil CO_2 efflux. Plant individuals were planted into field soil samples in small pots. Transpiration manipulation was done by regulating vapour pressure of the air around the plant canopy and by inhibitors. Photosynthesis manipulation consisted of programmed absence of light. Isotopic signatures of soil respiration were used for estimating the contribution of the autotrophic and heterotrophic soil respiration components. $13CO_2$ concentration of the CO_2 efflux of the different soil components was measured continuously in open system by cavity ring-down spectroscopy (Picarro G1101-i gas analyser). Keeling-plot approach was also used to calculate the isotopic signals of the sources.

According to the results, the effect of the assimilated CO_2 appeared after 3 hours in soil CO_2 efflux. The lack of light (24 hours) caused $\sim$20% decrease in total soil CO_2 efflux. The decrease of the plant transpiration rate slightly increased the autotrophic component. These responses could be useful in clarifying the drivers behind the diel variability of soil respiration.