Elevated atmospheric CO_2 concentrations results in increased CO_2 emissions by priming in a temperate heathland soil

Bengtson, P., Christensen, S., Vestergård, M., Reinsch, S. and Ambus, P.

Elevated CO_2 concentrations commonly result in at least a temporary increase in primary production and also in higher belowground allocation and exudation of recently fixed plant C. Evidence regarding the role of plant C allocated belowground for soil C sequestration and respiration are contradictory. On one hand there is evidence to suggest that plant C immobilized in mycorrhiza and other soil microorganisms significantly contribute to soil organic matter (SOM) formation. Other evidence suggests that root exudates can act as 'primers' that stimulate the decomposition and respiration of SOM. However, this is not always the case, since there are also instances where the microbial community preferentially assimilates the exuded C, resulting in decrease decomposition of soil organic matter

The aim of this experiment was to determine if increased belowground production in response to elevated CO_2 selects for a microbial community adapted to growing directly on the exuded C, or alternatively, a microbial community that use the exuded C to enhance SOM decomposition. Two scenarios can be conceived, 1. Increased root exudation results in preferential use of the exuded C, leading to decreased respiration of recalcitrant SOM (negative priming), and 2. Increased C exudation result in increased respiration of SOM (positive priming).

To test these alternative hypotheses we examined the magnitude and kinetics of priming in soil collected at a temperate heath/grassland in North Zealand, Denmark, that had been exposed to elevated CO_2 (+120 ppm) for 7 years. The maximum potential priming rate (V_{max}) and the half saturation constant (Km) was determined by adding ^{13}C-labelled glucose in varying concentrations (ranging from 0.06-4.0 mg glucose per gram soil) and fitting Michaelis-Menten saturation curves to the observed priming response.

Priming occurred at all soil depths in both treatments. The potential priming (Vmax) was 10-20 times higher in the top soil (0-10 cm) compared to the two deeper depths (10-30 and 30-50 cm). There was no difference between elevated and ambient CO_2 treatments with respect to the maximum potential priming (V_{max}) in the top soil. In contrast, the half saturation constant (Km) was lower in the elevated CO_2 treatment compared to the control. These results differed significantly from the two deeper soil layers. At these depths the priming was saturated already at the lowest glucose concentration. Furthermore, at these depths priming was higher in the control compared to elevated CO_2 treatment.

The results demonstrate that 7 years of elevated CO_2 significantly altered the belowground C cycling at the site. In the top soil the microbial community utilized the glucose to prime the decomposition of SOM with a higher efficiency compared to the control treatment, suggesting that CO_2 emissions caused by priming increased in response to the elevated CO_2 treatment. The same was not the case for the deeper soil layers, but since the vast majority of priming occurred in the top soil the results suggest that CO_2 emissions from soil caused by priming can be expected to significantly increase in a high CO_2 world.