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Nitrogen availability has a strong moderating effect on CO_2 emissions from soil caused by rhizosphere priming effects

Saeed Alaei [a], Birgit Wild [b] and Per Bengtson [a]

[a] Department of Biology, Microbial Ecology, Lund University, Sölvegatan 37, 223 62, Lund, Sweden

[b] Department of Earth Sciences, University of Gothenburg, Guldhedsgatan 5A, 40530 Gothenburg, Sweden

Labile carbon (C) compounds exuded by plant roots can significantly 'prime' soil organic matter (SOM) decomposition, resulting in increased emissions of CO_2 from soils. It is increasingly recognized that priming might be one of the quantitatively most important processes in the decomposition of SOM. Even so, the controlling factors, underlying molecular mechanisms and microorganisms involved in priming remains elusive. There are some indications that priming increases with increasing rates of labile C input, while input of labile C in combination with available N might have the opposite effect. A possible reason is that simultaneous input of C and N favors microbial 'cheaters' that do not decompose SOM, while input of only C 'prime' the decomposition of SOM by stimulating microbes that decomposes SOM in order to meet their N demand.

The objective of the experiment was to test this hypothesis and determine the effects of variations in C and N availability on the extent of priming and production of plant available nutrients. We also aimed at determining if priming mainly stimulates the oxidative decomposition of complex high molecular weight (HMW) SOM that release less complex polymers such as cellulose, starch and proteins with lower molecular weight (LMW), or alternatively, if priming stimulates the enzymatic decomposition of such LMW compounds directly. To test the hypothesis we designed a microcosm experiment where soil received daily additions of ^{13}C labelled glucose and inorganic N in varying concentrations during 15 days via an artificial root. Half of the microcosms received a mixture of proteins, cellulose and starch (henceforth LMW OM) in concentrations that increased the total SOM by 20% without altering the C:N ratio of the soil. Gas samples were taken every third day to quantify SOM respiration, glucose respiration and priming. At the end of the experiment, we also estimated gross N mineralization and ^{13}C retention in SOM and microbial biomass. The ability of the microorganisms to degrade C and N sources of varying complexity in the different treatments was tested using MT2 bioplates. The release of plant available inorganic N was tested by PRS probes installed in each treatment.

Initial results demonstrate that glucose additions induced priming at the two highest glucose addition rates in the treatment without LMW OM additions, with the strongest effect found in the treatment with the highest additions. In contrast, when glucose was added in combination with inorganic N we found positive priming at all three glucose addition rates. The highest priming was again found at the highest glucose addition rate, but the effect was an order of magnitude lower in this treatment compared to the treatment that did not receive inorganic N. In the treatments with soil pre-incubated with LMW OM, glucose addition resulted in strong negative priming at the two lowest glucose addition rates, and no priming at the highest. Addition of glucose in combination with inorganic N resulted in the opposite pattern, with high positive priming at all three glucose addition rates. The effect was most pronounced at the medium glucose addition rate and decreased at the highest. There was no consistent pattern that enabled us to conclude if priming mainly stimulates the oxidative decomposition of HMW SOM or the enzymatic decomposition of LMW SOM.

Taken together the results demonstrate that N availability strongly regulates the magnitude of priming that occurs in response to labile C input. At low input of labile C, N additions generally stimulated priming, while the opposite was true at high input of labile C. The strong moderating effect of N availability on priming needs to be accounted for in order to better understand and predict how soil CO_2 emissions will respond to increased belowground plant productivity at elevated atmospheric CO_2 concentration.