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Pyrogenic carbon losses and related priming effect on soil organic matter in a forest topsoil

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Pyrogenic carbon (PyC) is playing an important role in the terrestrial carbon cycle and due to its supposed natural resistance to mineralization in soil is considered to have potential as a C sink [1]. However many questions remain regarding the decomposition rate: most previous studies are rather short-term incubations or uncontrolled long term field samples [2, 3, 4, 5]. Moreover, in the long term, other factors can be important. For example, N deposition to soil is likely to play an important role for soil organic carbon mineralization [6, 7] including possible effects on PyC mineralization.

Our experimental design is a field manipulation experiment. The equivalent of 2.8 gC kg^{-1} of soil of ^{13}C (842 ‰) labelled powdered PyC has been added to the topsoil of a mixed temperate forest. A total of 12 mesocosms were installed. We added PyC to 6 of them, and kept 6 as control. Three mesocosms in each group also received monthly N additions as NH_4NO_3. We collected soil water samples below each mesocosm in order to estimate the losses by lisciviation. The flux and $d^{13}C$ of the CO_2 evolving from the mesocosm and the $d^{13}C$ signal in the dissolved organic carbon (DOC) were measured to quantify the mineralization rate and the losses in soil water of PyC over one year. We computed the $d^{13}C$ signature of the CO_2 fluxes using the Keeling plot method. CO_2fluxes have been measured using an infrared gas analyser.

After one year 1) approx. 0.74% of added C-PyC was mineralized as CO2; 2) N application to soil decreased the amount of PyC decomposed of ca. 50%; and 3) the quantity of PyC lost in soil water was negligible. A large priming effect of pyrogenic carbon was observed: the average of 12 sampling dates over 8 months of measurements showed that PyC increased native CO_2 fluxes by 28%. This might produce a loss of soil organic carbon over a period of few years which is comparable to the quantity of PyC stored in the soil, challenging the use of PyC as a carbon sink. However we observed that mineral N addition to soil reduced priming effect. We conclude that PyC is decomposing at rates which are of the same order of magnitude of previous estimates and that the priming effect was definitely not negligible. Both PyC decomposition and its priming effect can be reduced by N addition to soil.

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