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Biochar Decomposition in Agricultural Soils of Temperate Climate

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Biochar has a great potential to ameliorate agricultural soils, especially those that are low in organic matter. Photosynthetically fixed atmospheric CO_2 stabilized in biochar may thus act as a direct carbon sink and help to mitigate climate change, as it is supposed to remain for hundreds of years in soil. But biochar turnover times seem to depend not only on biochar itself, but also on soil and climatic conditions. Thus predictions of effects on soil micro-biota and how biochar decomposition is affected need to consider biochar and soil properties case by case.
In this study, biochar-derived carbon fluxes to the atmosphere, the soil organic carbon pool (C_{org}) and the active microbial biomass carbon pool (C_{mic}) were investigated in the course of an aerobic incubation experiment at room temperature in the dark. The investigation was performed using two loess soils from the DOK long-term system comparison experiment located in Therwil, Switzerland. The two soils received composted manure or mineral fertilizers in the past 28 years. Both soils were amended with two distinct biochars and their feedstock material as a control. The biochars were produced by pyrolysis (pyrochar) and hydrothermal carbonization (HTC; hydrochar). The maize feedstock (*Zea mays, L.)* used to produce biochar was highly enriched in ^{13}C. Soil C mineralization was monitored continuously; $C_{mic}$and C_{org} were measured at two distinct time points, after the initial peak in mineralization (14 days) and after return to a constant CO_2 evolution rate in all treatments (205 days). The fluxes were assessed by stable isotope techniques, measuring $^{13}CO_2$, $^{13}C_{mic}$ and $^{13}C_{org}$ in bulk soil to enable the calculation of biochar turnover times in soil.
In both soils the biochar mineralization pattern, measured as C flux from soil into air, was very similar. Only initial mineralization rates of maize straw and hydrochar were higher in soil M, whereas pyrochar was decomposed slightly faster in soil D. Hydrochar derived carbon was readily incorporated in the microbial biomass of both soils, pyrochar resisted nearly completely. The comparison of the three carbon pools at day 12 and day 205 shows that a stabilization of maize feedstock of more than a double could be achieved by HTC and far beyond that scale by pyrolysis. This study shows that the HTC technique, which is promising for wet biological wastes, never matches the carbon sequestration potential of pyrolysis.