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Thermal stability of soil organic matter pools is not related to the biological availability of C and N under elevated CO_2

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CO_2 applied for Free-Air CO_2 Enrichment (FACE) experiments is strongly depleted by ^{13}C and thus provides an opportunity to study C turnover in soil organic matter (SOM) based on its δ^{13}C value. Simultaneous use of ^{15}N labeled fertilizers allows N turnover to be studied. Various SOM fractionation approaches (fractionation by density, particle size, chemical extractability etc.) were applied to estimate C and N turnover rates in SOM pools. The thermal stability of SOM coupled with C and N isotopic analyses has never been studied in experiments with FACE. We tested the hypothesis that the biological availability of SOM pools is inversely proportional to their thermal stability. Soil samples from FACE plots under ambient (370 ppm) and elevated CO_2 (540 ppm; for 3 years) treatments were analyzed by thermogravimetry coupled with differential scanning calorimetry (TG-DSC). Based on differential weight losses (TG) and energy release or consumption (DSC), five SOM pools were distinguished. Soil samples were heated up to the respective temperature and the remaining soil was analyzed for δ^{13}C and δ^{15}N by IRMS. Energy consumption and mass losses in the temperature range 20-200 ˚C were mainly connected with water volatilization. The maximum weight losses occurred from 200-310 ˚C. This pool contained the largest amount of carbon: 61% and 63% in soil under ambient and elevated CO_2, respectively. δ^{13}C values of SOM pools under elevated CO_2 treatment showed an increase from -34.3‰ of the pool decomposed between 20-200 ˚C to -18.1‰ above 480 ˚C. The incorporation of new C and N into SOM pools was not related to their thermal stability. Those SOM pools decomposed between 200-310 ˚C and 400-480 ˚C had 4 and

8% of new C, with a mean residence time (MRT) of 94 and 25 years, respectively. The pool decomposed between 310-400 ˚C had the largest amount of new C (21%), with an MRT of 13 years. The amount of fertilizer-derived N after 2 years of application in ambient and elevated CO_2 treatments was not significantly different in SOM pools decomposed up to 480 ˚C (3.5%), with an MRT of about 60 years. In contrast, the pool decomposed above 480 ˚C had only 0.3% of new N, with an MRT of more than 2000 years in soils under both treatments. Thus, ^{13}C and ^{15}N incorporation into SOM pools and their MRT were not dependent on increasing thermal stability of the pools. Accordingly, the hypothesis fails: there was no relation between biological availability of SOM pools and their thermal stability.