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Stable C isotopes of soil organic matter in deep agricultural Danish soils

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Soil organic matter is a thoroughly studied yet not fully understood soil constituent. The various turnover rates and qualities of such pools only complicate investigation. However, stable carbon isotopes are a powerful tool to study soil system processes, and hence give the chance of a greater insight into the nature of soil organic matter.

Here, it is attempted to constrain the transport and turnover of plant-derived organic matter by the use of stable C isotopes taking advantage of C3-C4 plant shifts.
Two field sites subjected to a spring barley- to silage maize crop shift were selected for this purpose. The sites are located just outside Humlum and Vildbjerg in Western Jutland, Denmark. The field sites have had maize crops continuously during the last fourteen and twelve years respectively. Triplicate soil cores from the two field sites were excavated down to 1.6 m depth. Additionally, soil cores from neighbouring control fields, kept with C3 plants only, were collected. The Humlum soil consist of clay-rich meltwater deposits, whereas the Vildbjerg soil consist of sandy meltwater-deposits. Grain size distribution is the most prominent difference between the two sites.

Samples were partitioned into depth intervals based on soil characteristics. Bulk soil material was analysed for total C and δ^{13}C by IRMS.

Respiration experiments were performed on field moist soil. Subsamples were inserted in sealed jars at 20 ˚C in ambient atmosphere. Headspace gas was sampled at 0, 24, 48, 72 and 144 hours. Gas sample concentration and δ^{13}C of the evolved CO_2 were analysed by IRMS.

For the Vildbjerg site, no significant difference was seen between the maize- and control field in bulk soil C-concentration nor in bulk soil δ^{13}C.

The Humlum site did not show any significant difference in bulk soil C-concentration between the maize- and the control field. However, the Ap horizon of the maize field had a less negative δ^{13}C value compared to the Ap horizon of the control field. This is in accordance with the C3-C4 plant shift.

The incubations resulted in respired $CO_2$with less negative δ^{13}C from both maize fields sites compared to the control fields. For the Vildbjerg soil, this discrimination was evident to a depth of 40 cm, whereas for the Humlum soil the difference was seen to at least 80 cm. The C4 plant-derived organic carbon only constitutes a minor portion of the total C pool, due to little contribution to the δ^{13}C of the bulk soil. However, the recently introduced maize-derived organic matter proved to respire easily, and hence was more labile than the older persistent carbon pool, which held more negative δ^{13}C signatures.

The comparable crop histories of the two maize fields make it plausible that the input of maize-derived organic matter has been similar at both sites. Consequently, differences in δ^{13}C signatures between the two sites are likely to be the result of different soil properties.