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Carbon dioxide emissions from agricultural soils amended with livestock-derived organic materials

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Carbon dioxide gas xchange between terrestrial ecosystems and the atmosphere, as well as the carbon sink strength of various arable land ecosystems, is of primary interest for global change research. Measures for increasing soil C inputs include the preferential use of livestock-derived organic materials (e.g. animal manure and slurries, digestate from biogas production plants and compost). The application of such materials to agricultural soils returns essential nutrients for plant growth and organic matter to maintain long-term fertility. Whether or not such practices ultimately result in sustained C sequestration at the ecosystem level will depend on their mineralization rates.

This work presents preliminary results from a laboratory incubation trial to evaluate carbon dioxide fluxes from two agricultural soils (a calcareous silt loam and a silty clay loam) amended with agricultural doses of (i) pig slurry (PSL), (ii) the digestate from the anaerobic fermentation of pig slurries (AAS) and (ii) a compost from the aerobic stabilisation of the digestate (LDC). These subsequent steps of slurry stabilisation resulted in a decrease in the content of labile organic matter which was reflected in a reduction in maximum carbon dioxide emission rates from amended soils. Measurements have shown that peak emissions from soils occur immediately after application of these organic materials (within 5 days) and decrease in the order PSL > AAS > LDC. Moreover, mean cumulative emissions over the first 40 days showed that a higher percentage (about 44%) of the C added with PSL was mineralised respect to C added with AAS (39%) and LDC (25%). Although it was hypothesised that apart from the quantity and stability of the added organic materials, even soil characteristics could influence C mineralisation rates, no significant differences were observed between emission fluxes for similarly treated soils. Mean cumulative emission fluxes after 40 days from treatment were of 114, 103 and 84 g C m-2 for PSL, AAS and LDC respectively.

Carbon dioxide emission rates were corroborated with results obtained from the quantification of water-extractable organic C (WEOC) and soil microbial biomass-C (Cmic). The former represents the more labile fraction of soil organic matter and its concentration in the freshly amended soils followed the order LDC > AAS ≈ PSL. However, whereas WEOC concentrations decrease rapidly for PSL and LDC amended soils, AAS treated soils showed a steady increase during the first 20 days of incubation followed by a decrease thereafter. This was attributed to the release of soluble organic matter from the anaerobically stabilised digestate in the presence of an aerobic soil microbial community. Irrespective of the type of amendment, Cmic values increased with time with respect to the unamended controls, reaching highest values after 20 days from amendment and decreasing thereafter. Even after 40 days of incubation, Cmic values in all amended soils did not return to the background values obtained with unamended controls.

These results suggest that the application of stabilised livestock-derived organic materials to soils may play an important role in reducing C emissions associated with agricultural practices and increase soil C stocks, apart from other indirect beneficial effects such as the recovery of energy from combustion of biogas from anaerobic fermentation of these waste materials.