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Exploring the Impacts of Digestate Application on the Carbon Cycle in Grassland Soils

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Digestate may be applied to agricultural soils as a replacement for inorganic fertilizer, but also potentially acting as a soil conditioner (e.g. increasing soil organic carbon [SOC] levels). However, digestate application to agricultural soil can have varied interactions with microorganisms in the soil, depending on factors such as the quality of digestate applied (e.g. in terms of C:N ratio) and soil nutrient status. The net balance of these interactions affects the carbon use efficiency [CUE], which is defined as the capability of microorganisms to use organic carbon sources for growth. High CUE generally occurs when microorganisms are growing mainly using C from exogenous sources (anabolic pathway favoured), leading to a SOC stabilization. Low CUE occurs when bacteria are not using the C source efficiently (catabolic pathway favoured), leading to elevated soil respiration, CO_2 production and reduced net C sequestration. Soil nutrient status (C, N, P level) can influence positively or negatively the CUE. Organic materials with C:N <20 applied to a high nutrient soil (rich in C, N and P) increase the CUE, whilst their application to a low nutrient soil (depleted in C, N and P) decreases it. Contrastingly, organic materials with C:N >20 (lignin-like) are virtually inaccessible to microbial decomposition in the short term, thus no effect on CUE is expected. Based on this context, the aim of the experiment described here was to understand how different digestate fractions (whole [WD] C:N=4 and solid [SD] C:N=22) applied at a fixed dose (170 Kg NH_4/ha/y) affected CUE in two soils with contrasting fertility (high and low plant-available nutrients).

A 21-d incubation under controlled conditions was carried out (T=23°C) to assess soil microbial responses. Soil respiration was continually monitored using an automated respirometer and a set of destructive samples were prepared to analyse the changes in microbial biomass C (C_{micro}). In both soils, C_{micro} increased strongly following SD addition, while WD was only associated with increased C_{micro} in the high nutrient soil. The rate of CO_2 efflux from the high nutrient soil was strongly promoted by WD application, yet this rate decreased rapidly after day 7 of the incubation. In comparison, maximum CO_2 efflux rates were lower under the SD treatment, yet this rate did not decrease through the 21-d incubation. In the low nutrient soil, maximum CO_2efflux rates were slightly higher under SD compared to WD treatment, and again SD efflux remained relatively constant throughout the incubation, whilst WD efflux decreased after 96h. Our results suggest that varying CUE responses are likely to be observed following the application of digestate to agricultural soils, dependent on C-source (digestate fraction) and on the initial nutrient status of the receiving soil. Under certain circumstances, digestate application may lead to an increased CO_2 efflux from soils and a decrease of SOC. Therefore, digestate application rates and soil management should be carefully planned in order to avoid adverse impacts of digestate application to land.