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Does microbial metabolism trigger increase of grassland soil carbon stocks upon mineral fertilization?

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Fertilization with the major plant nutrients nitrogen (N), phosphorus (P), and potassium (K) can affect soil organic carbon (SOC) stocks of grassland soils, e.g. by altering above- and belowground plant productivity, species composition, litter composition and decomposition as well as microbial metabolism. Change in each of these mentioned components may trigger changes in SOC stocks. In this study, seven different long-term grassland fertilization experiments (16-58 years) in Germany and the Netherlands were investigated to determine the effects of mineral fertilization (i.e. N, P, K, PK, and NPK) compared with unfertilized plots (Control) on SOC stocks and root C stocks, potential litter decomposition and root C:N ratios. Soils were sampled to a depth of 100 cm or to the maximum depth possible. In the topsoil (0-30 cm depth), PK, NPK, and NPK+ (increased NPK) fertilization had significant positive effects on SOC stocks, with annual sequestration rates of 0.28, 0.13, and 0.37 Mg ha-1 yr-1, respectively, within an average time span of 34 (PK, NPK) or 20 (NPK+) years. For NPK fertilization, 1.15 kg of N was needed to sequester 1 kg SOC. Root C stocks tended to decrease with fertilization, which precludes a possible link of SOC accumulation to root C inputs. Potential litter decomposition assessed using Lipton Rooibos and Green tea decomposition rates was unchanged. The highly significant increases in dry matter yield with PK and NPK fertilization and resulting higher aboveground C inputs were also unlikely to explain the observed SOC stock changes, since increases were only observed at soil depths >10 cm. However, significantly narrower root C:N ratio ranges were observed for the N (26.9), PK (36.5), NPK (36.8), and NPK+ (33.2) treatments than for the Control (41.8), which might have affected microbial C use efficiency. The latter was subsequently assessed in an incubation experiment using a novel 18O tracing method. We discuss how the availability of nutrients influence the SOC turnover in grasslands triggered by shifts in the carbon use efficiency of the soil fauna.