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Organic phosphorus mineralisation in a temperate grassland soil under elevated atmospheric carbon dioxide concentrations

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Background: Phosphorus (P) is an essential nutrient for all biota and significant proportions of P in soil are present in organic form. Increased atmospheric concentrations of carbon dioxide ([CO_2]) have been shown to influence plant P uptake traits, resulting in plant-mediated changes in soil P pools. However, little is known on the effect of elevated [CO_2] on organic P mineralisation rates in soil.

Study design & hypotheses: A ^{33}P isotopic dilution experiment was performed with soils of the 17-year-old Giessen free air carbon dioxide enrichment (GiFACE) – trial. At the GiFACE, three plots are treated with 20 % elevated [CO_2] while three control plots receive ambient air. We hypothesised that i) the observed positive effect of elevated [CO_2] on plant growth translates into differences in soil organic P mineralisation rates between treated and untreated plots, resulting in ii) differences in soil organic P pools.

Methods: Fresh soil (0-8 cm) was sampled from each plot, labelled with a carrier free ^{33}P solution and incubated for 36 days at 19˚C in the dark. On six time points, inorganic P and ^{33}P in soil filtrates, soil microorganisms (by liquid fumigation) and resin extractable P were quantified. The baseline of ^{33}P isotopic dilution was assessed from a short term batch experiment and extrapolated for 36 days. Gross organic P mineralisation rates were determined as the difference between isotopic dilution in the incubated soils (physicochemical + biological processes) minus extrapolated values (physicochemical processes only). Additionally, enzyme addition assays on alkaline soil extracts were performed to quantify different soil organic P classes, using enzymes with a known substrate specificity.

Results & Discussion: Gross organic P mineralisation rates were high during the first three days (5.5 – 34.3 mg P kg^{-1} d^{-1}), possibly due to the soil disturbance at labelling soils with ^{33}P. However, gross organic P mineralisation decreased rapidly to rates between 0.7 and 4.2 mg P kg^{-1} d^{-1}. Net organic P mineralisation during this phase was quantified by subtracting microbial P immobilisation and ranged between 0.3 and 3.4 mg P kg^{-1} d^{-1}. We did not detect a significant effect of elevated [CO_2] on soil organic P transformation rates, however, relatively high P fertilisation since the start of the GiFACE-trial (equal to 5.6 g P m^{-2}) may have masked subtle changes in mineralisation rates. Significantly higher concentrations of phytate-like P were found in plots treated with elevated [CO_2]. We assume that increased plant biomass production under elevated [CO_2] caused the formation of more inositol-hexakisphosphate (phytate), a P storage compound in plants.

Conclusions & Outlook: Elevated [CO_2] had no clear effect on soil organic P mineralisation rates, but soil organic P classes were clearly affected. Organic P transformation rates will also be verified with a recently developed numerical model.