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Phosphorus biogeochemistry differs in rhizosphere compared to bulk soils in long-term wheat fertilization trials in Saskatchewan, Canada

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Many soils need phosphorus (P) fertilization for optimal crop yields. Maintaining crop growth while minimizing loss of excess P requires knowledge of P biogeochemistry, both of P speciation and of the biochemical processes governing P cycling. These will vary spatially, with bulk soil differing from the root zone (rhizosphere), and with crop rotation and management practices. Rhizosphere and bulk soils were sampled in Swift Current, SK, Canada from treatments including: annual wheat plots established in 1967 (AW) with nitrogen (N) and P fertilization or with P fertilization alone; plots established in 1982 with lentils (an N-fixing legume) and wheat (WL) in alternate years with N and P in the wheat phase only; and subplots where P fertilization stopped in 1995 for AW and in 2008 for WL. Samples were analyzed for soil pH and cations, and for a range of P pools including total and organic P, soil test P, and sequential fractionation. Phosphorus speciation was determined by P-NMR and P k-edge XANES spectroscopies. Soil processes were examined with *in situ* phosphate release by anion-exchange resin and P enzyme activity assays (acid and alkaline phosphomonoesterase, phosphodiesterase), while qPCR was used to estimate the abundance of fungal and bacterial communities. Significant differences were determined for fertilization treatment and spatial position, but there were no significant interactions of treatment*position. Soil acidification from N fertilizers significantly decreased soil pH in AW plots, from 6.5 in plots without N to 5.5 in plots with N. Acidification to pH 5.5 was also determined in the WL plots; although they received half the N fertilizer, biological N fixation is an acidifying process. Acidification altered soil cations, decreasing calcium and increasing iron and aluminum, which in turn altered P speciation. Acidification also altered enzyme activities. Stopping P fertilization reduced P concentrations in many pools, but did not affect crop yield. Spatially, soil processes were increased in rhizosphere soils relative to bulk soils regardless of fertilizer treatment, with increased enzyme activities and changes in microbial community abundance. These results clearly demonstrate that geochemical and biochemical data are needed to understand P cycling and manage P in cropping systems.