Inositol phosphates in soil: the enigma of the phosphorylated stereoisomers

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Inositol phosphates are the most abundant form of organic phosphorus in most soils, and occur in forms that exist nowhere else in nature (Turner *et al*., 2002). The origin and ecological function of these compounds remain largely unknown, which is remarkable given the importance of phosphorus in biological processes.

Four stereoisomeric forms of phosphorylated inositols occur in soils (Figure 1). Of these, the *myo* isomer is most common, which is unsurprising as it occurs widely in plants. In contrast, highly phosphorylated forms of the other three isomers occur extremely rarely elsewhere.

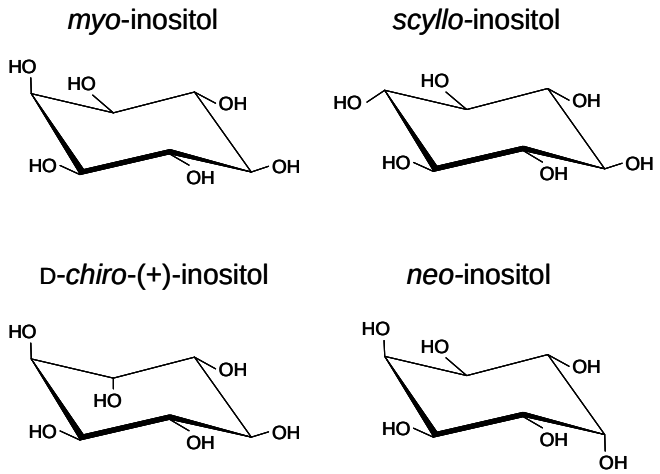

Figure 1. The four stereosimeric forms of phosphorylated inositols detected in soils.

Inositol phosphates pose a problem for our ecological understanding of soil biogeochemical cycles and the nutrition of plants and organisms. Specifically, inositol phosphates accumulate in soils and are considered to be of limited availability to organisms. However, they persist in environments in which productivity is strongly limited by phosphorus availability, which seems paradoxical given the remarkable ability of evolution to equip organisms with the tools to exploit resources in their environment. This suggests that soil inositol phosphates may have a non-nutritional function in soils, although precisely what this function is remains unclear.

Given that highly phosphorylated inositols other than the *myo* isomer have not been detected in the tissue of plants, nor in any soil organisms, the origin of these compounds in soil remains unknown. It seems likely that they have a microbial source, but it is unclear why organisms should synthesize stereoisomers other than the *myo* form that is so prevalent in nature.

Analytical methodology has limited studies on inositol phosphates in soils. Problems with conventional chromatography mean that much of the older literature must be considered with caution. Hypobromite oxidation is an important procedure for quantifying higher inositol

phosphates by solution ^{31}P NMR spectroscopy (Turner and Richardson, 2004). Figure 2 demonstrates the improvement in resolution and signal identification that can be achieved using hypobromite oxidation of alkaline soil extracts.

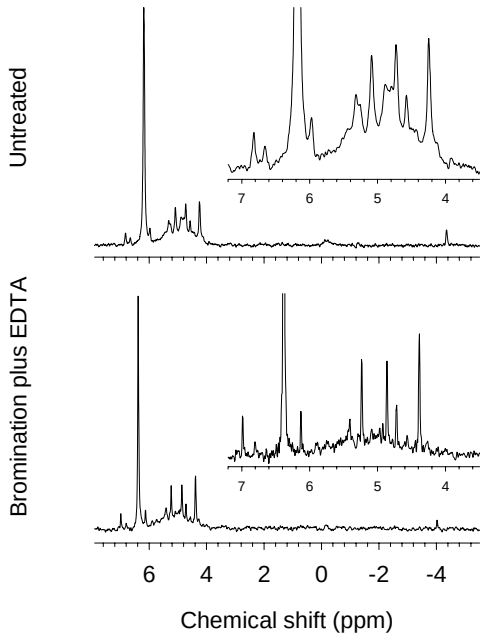

Figure 2. Solution ^{31}P NMR spectra of an NaOH–EDTA extract of a temperate pasture soil, analyzed directly (top) or after hypobromite oxidation organic matter other than the inositol phosphates.

Despite several comprehensive studies of inositol phosphates in many soils, few factors have emerged as key regulators of concentrations or proportions of the soil organic phosphate. From my own studies, it is clear that inositol phosphates can account for between none and almost all of the organic phosphate extractable in alkali. It is noteworthy that they were not detected in high organic matter soils from the Florida Everglades (Turner and Newman, 2005). Other soils contain more *scyllo*-inositol phosphates than the *myo* forms, but it is unclear why this is the case. When soils under similar vegetation, climate, and land-use are analyzed, there is evidence that the hexaphosphates accumulate in soils with low N:P ratios (Turner *et al*., 2003; 2005). This suggests that organisms that can degrade inositol phosphates may be favored in soils with low P availability.

References

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