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Solubilization of insoluble inorganic phosphate by microorganisms in acidic forest soils

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Phosphorus (P) is the second most important element after nitrogen for plant nutrition. Most P in soils is bound to metal(hydro-)oxides (Al, Fe, Ca), and hence often less than 0.1% of total P is bioavailable. A broad group of soil microbes, collectively called phosphate-solubilizing microorganisms (PSM), is capable of releasing P bound to minerals, and transforming it into soluble, plant-available forms. The mechanisms by which PSM solubilize P are still poorly understood. The objective of this study was to explore the ability of PSM to solubilize P from hydroxyapatite and goethite. For this purpose, incubation experiments with hydroxyapatite and P-loaded goethite in solutions containing bacteria from five acidic forest soils were conducted, either with or without addition of glucose. Also, we conducted control experiments to correct for P mineralization in the soil solution. The PSM progressively solubilized P from hydroxyapatite and P-loaded goethite over the course of 14 days. The rate of P solubilization was significantly larger (by factor 2.3 to 10.2) for hydroxyapatite than for goethite. Microbial acidification of the soil solution was the main reason for the release of mineral-bound P. Microorganisms released citric and gluconic acid in all experiments; in addition, oxalic and 2-ketogluconic acid were released in the experiments with hydroxyapatite. The rate of P solubilization was strongly increased by the addition of glucose, probably due to the larger production of low molecular weight organic acids. This suggests that microbial P solubilization is strongly carbon-limited. In conclusion, our findings provide evidence that PSM can effectively counteract low bioavailability of P in soils by solubilizing mineral-associated P, especially when provided with a carbon source.

Keywords: microbial solubilization, hydroxyapatite, goethite-P