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Patterns of low-molecular-weight organic acids exuded by roots along a unique precipitation gradient at the Coastal Cordillera of Chile

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Low-molecular-weight organic acids (LMWOA) are crucial for nutrient mobilization in soil by roots. By chelating bivalent cations and lowering soil solution pH, the release of LMWOA promotes the dissolution of phosphorus (P) and iron (Fe) bearing minerals and inhibits the precipitation of secondary P minerals. LMWOA therefore contribute directly to the weathering of the parent rocks and to plant nutrition. A better understanding of these processes requires a closer look at these root derived compounds and their persistence in soil.

We sampled soil derived from granitic material from three sites located in the Chilean Coastal Cordillera. These sites represent a gradient of mean annual precipitation (MAP) from 150 mm/a in the north to 1500 mm/a in the south. This gradient provides a unique opportunity to examine the influence of MAP on soil processes induced by plants and the soil microbial community.

Plants were labelled with 13 C under field conditions. A representative plant species was selected for each site. Concentrations of seven dominant di- and tricarboxylic LMWOA were quantified in the upper 30 cm of the soil. Sampling was done 1 day, 3 days and 14 days after the labeling. Using sequential extraction, we distinguished between water-soluble and mineral-associated LMWOA. After esterification to the corresponding di- or trimethyl esters, LMWOA were quantified by gas chromatography mass spectrometry, the 13 C / 12 C ratio was measured by gas chromatography combustion isotope ratio mass spectrometry.

The results show that citric and oxalic acid are the most abundant LMWOA in these soils. Concentrations of LMWOA increased along the gradient with increasing precipitation, i.e. net primary production of the ecosystem, and decreased with increasing soil depth. 13 C incorporation was largest in oxalic-, malic- and citric acid – representing most likely direct root exudates. Considering the difference between the water-soluble and the mineral-associated fraction the incorporation of 13 C was much lower in the latter one, indicating a slower turnover of mineral-associated acids. Therefore, contribution of LMWOA to mineral weathering in these soils acts as a long-term process rather than a response to seasonal shortcoming in nutrients.