Processes controlling phosphate acquisition by plants as revealed by coupled root system-reactive transport modelling

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Phosphate (P) solubility is limited in soils, but is essential for plants. High P fertilization is not sustainable and causes environmental damages. A solution to decrease P fertilization while sustaining plant growth could be to solubilize soil P in the root zone in order to increase P availability to plants. However, a range of biogeochemical processes control P availability. We developed a new soil-plant model [1] that can simulate solute uptake by taking into account rhizosphere processes according to a comprehensive description of both reactive transport [2] and root system processes [3].

We will present results of an application of this new model to P acquisition by maize in alkaline soils in order to illustrate its capacity to investigate P-controlling processes in the rhizosphere. We used surface complexation modeling to simulate the dependency of P adsorption/desorption on pH and Ca concentration. P-mineral dissolution was simulated using a kinetic expression based on the Transition State Theory. Results are compared with literature data in an attempt to assess processes controlling P-availability for maize grown in an alkaline soil.

Results showed that the increase of P availability with acidification widely observed in the field requires some P-release by mineral dissolution. Otherwise P availability decreases because of greater adsorption. Conversely, P-release from desorption and dissolution could not reproduce the increase of P availability typically observed in the absence of pH variations or under conditions of alkalinization in the maize rhizosphere. This discrepancy re-emphasizes the complexity of P-cycling soils and demonstrates the need for further investigation.

[1] Gérard F. *et al.* (2016) *Plant Soil* **DOI: 10.1007/s11104-016-3092-x**. [2] Mayer *et al.* (2002). *Water Resour. Res.* 38, 1174-1195. [3] Pagès F. *et al.* (2014) *Ecol. Model.* **290**, 76-84.