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

F. GÉRARD$^{1}$*, S. BEA$^{2}$, L. PAGÈS$^{3}$, P. HINSINGER$^{1}$, K.U. MAYER$^{4}$

$^{1}$INRA, UMR Eco&Sols, Montpellier, France
(*correspondence: frederic.gerard@inra.fr)
$^{2}$CONICET, Large Plains Hydrology Institute, Buenos Aires, Argentina (sabea@fia.unicen.edu.ar)
$^{3}$INRA, UR PSH, Avignon, France (loic.pages@inra.fr)
$^{4}$UBC, Earth, Ocean and Atmospheric Sciences, Vancouver, Canada (umayer@eos.ubc.ca)

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 alkalization in the maize rhizosphere. This discrepancy re-emphasizes the complexity of P-cycling soils and demonstrates the need for further investigation.