International Symposium “Root Research and Applications”
RootRAP, 2–4 September 2009, Boku – Vienna, Austria

Comparison of nutrient uptake between an averaged root system model and true 3D simulation

Daniel Leitner[1], Sabine Klepsch[1,2], Richard Grabner[3] and Andrea Schnepf[1]

1: University of Natural Resources and Applied Life Sciences, Vienna, Institute of Soil Research, Peter-Jordan Strasse 82, A-1190 Vienna, Austria
2: Austrian Research Centers GmbH – ARC, A-2444 Seibersdorf, Austria
3: Vienna Technical University, Institute for Analysis and Scientific Computing, Wiedner Hauptstr. 8-10, A-1040 Vienna, Austria

Simulation is an important tool when analysing the mechanisms within the rhizosphere. In this work we discuss the impact of individual roots and rhizosphere traits on nutrient uptake by a whole root system.

Due to the complexity of large root systems 3D simulations are often not feasible. Thus the use of up-scaling techniques such as averaging or homogenisation is of major importance. The scope of this work is to present a method that compares these approximations to true 3D simulations for small parts of a root system.

In order to obtain realistic 3D uptake models, root architecture models are coupled with soil models where the interactions between plant roots and soil are described by boundary conditions at the root surfaces. In averaged models, the root system uptake is represented by a sink term which is dependent on the local root length density. However, effects which are dependent on local root geometry like overlapping depletion zones are neglected. In order to estimate the error which is introduced by this simplification we compare the averaged root system model to true 3D simulation. For the dynamic root system growth we use a model based on L-Systems which returns segments of individual roots. We use the mesh generator Distmesh, which uses a force-based smoothing procedure to optimize the node locations, to obtain a finite element mesh of the geometry. The mesh is then imported in Comsol Multiphysics, a finite element solver for the solution of partial differential equations, to calculate nutrient uptake by a 3D root system.

Finally we discuss the differences of the simulated nutrient uptake by a whole root system as calculated by the averaged model and true 3D simulation.