"An upscaling model describing root radial hydraulic conductivity from cross section anatomy and aquaporin expression patterns"

Couvreur, Valentin ; Faget, Marc ; Javaux, Mathieu ; Chaumont, Francois ; Draye, Xavier

Abstract

Objectives: To improve our understanding of aquaporin (AQP) expression patterns and root anatomy effects on radial hydraulic conductivity by combining quantitative in vivo and in silico experiments from the cell to the root cross-section scales in various hydric environments. Methods: A program generates explicit 2D root cross-section hydraulic networks from cross-section anatomy images. The hydraulic network includes "cell wall" and "intra cell" nodes constituting connected pathways allowing water flow from the root surface to xylem vessels using the transmembrane, apoplastic and symplastic pathways. Cell layers have hydraulic properties that depend on plasma membrane AQP abundance and apoplastic barrier deposition. Water flow equations are solved to compute water potentials and fluxes in each node of the system. The radial hydraulic conductivity of the root cross section can then be calculated. Results: We created a mathematical model linking the radial conductivities of root segme...

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An upscaling model describing root radial hydraulic conductivity from cross section anatomy and aquaporin expression patterns.

Marc Faget[1], Valentin Couvreur[1], Mathieu Javaux[2], François Chaumont[3] and Xavier Draye[1].
[1] Earth and Life Institute – Agronomy, Université catholique de Louvain, Belgium
[2] Earth and Life Institute – Environment, Université catholique de Louvain, Belgium
[3] Institut des Sciences de la Vie, Université catholique de Louvain, Belgium

Objectives: To improve our understanding of aquaporin (AQP) expression patterns and root anatomy effects on radial hydraulic conductivity by combining quantitative *in vivo* and *in silico* experiments from the cell to the root cross-section scales in various hydric environments.

Methods: A program generates explicit 2D root cross-section hydraulic networks from cross-section anatomy images. The hydraulic network includes "cell wall" and "intra cell" nodes constituting connected pathways allowing water flow from the root surface to xylem vessels using the transmembrane, apoplastic and symplastic pathways. Cell layers have hydraulic properties that depend on plasma membrane AQP abundance and apoplastic barrier deposition. Water flow equations are solved to compute water potentials and fluxes in each node of the system. The radial hydraulic conductivity of the root cross section can then be calculated.

Results: We created a mathematical model linking the radial conductivities of root segments to a minimal set of quantitative molecular (AQP expression) and explicit anatomical data. The model distinguishes apoplastic, symplastic and transmembrane pathways within the root tissues and integrates the temporal scales of AQP regulation and apoplastic barrier formation which drive root hydraulic properties.

Interpretation: The data obtained during the project lead to a better understanding of the constraints that drive AQP expression patterns and apoplastic barrier deposition. This new model is intended to replace the empirical rules that were used in pioneer models of water dynamics in the soil-plant system. It is expected to become a tool that will bridge the gap between protein regulatory pathways operating at the cell level, hydraulic behaviour at higher levels and strategies of plant water use, which constraints the success of crop water acquisition in various drought scenarios.