# Mechanistic numerical modelling of solute uptake by plant roots

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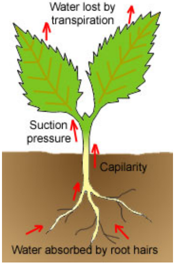
# Outline

# Introdução




Desenvolvimento e produção

$\equiv$

transpiração da planta


Estresse (biótico/abiótico)

$\downarrow$

Fechamento dos estômatos

$\downarrow$

Alteração na transpiração

Revisão dos modelos existentes (inclusive o do Quirijn)

Modelo proposto. Explicação de como funciona e caracterização.

# Introdução

- Encontrar um modelo que explique suficientemente bem o fenomeno para o propósito escolhido;
- Relação número de parâmetros/grau de complexidade do modelo difícil de ser ajustado;
- Encontrar simplificações que tornem a resolução possível, perdendo o mínimo possível de precisão (realidade X simulação).

Modelagem $\rightarrow$ entender/simular/prever os fenômenos

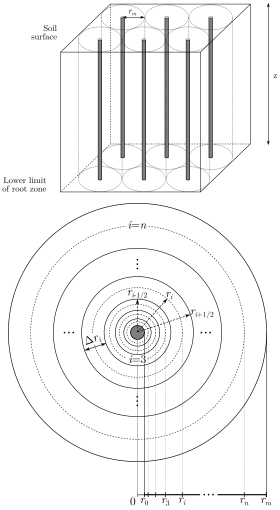
$\downarrow$

melhorar práticas de manejo das culturas

Os objetivos da tese são

- Incorporar extração de soluto no modelo de De Jong van Lier et al. (2009);
- Diferenciar quantitativamente as componentes passiva e ativa da extração de solutos;

# Características do domínio




Equação de Richards

$$\frac{\partial \theta}{\partial t} = \frac{1}{r}\frac{\partial}{\partial r}\left(rK(h)\frac{\partial H}{\partial r}\right)$$

Equação de Convecção-Dispersão

$$r\frac{\partial(\theta C)}{\partial t} = -\frac{\partial}{\partial r}\Big(rqC\Big) + \frac{\partial}{\partial r}\left(rD\frac{\partial C}{\partial r}\right)$$

Condições de contorno em $r_0$:

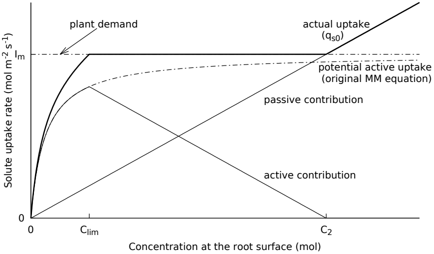
Água:

$$K(h)\frac{\partial h}{\partial r} = q_0 = \frac{T_p}{2\pi r_0 Rz}$$

Soluto:

$$-D(\theta)\frac{\partial C}{\partial r} + q_0 C_0 = q_{s0} = -\frac{F}{2\pi r_0 Rz}$$

# Condição de cotorno em $r_0$




Extração de soluto dependente da concentração de soluto no solo (MM equation)

$$F = \begin{cases} \dfrac{I_m C_0}{K_m + C_0} + q_0 C_0, & \text{if } C_0 < C_{lim} \\ I_m, & \text{if } C_{lim} \leq C_0 \leq C_2 \\ q_0 C_0, & \text{if } C_0 > C_2 \end{cases}$$

## Numerical implementation of CDE equation

## Other solute uptake models

# Other analysis

- Sensitivity analysis
- Statistical difference

## Models results

# Conclusions

- Linear and non-linear uptake solutions show good agreement with an analytical solution which also considers a concentration dependent uptake as the boundary condition at the root surface. They are significantly different only when comparing the concentration as a function of time for times where $C_0 < C_{lim}$ (NUP).
- A second reduction in the $T_r$ may occur by a reduction of the solute uptake rate resulting in a reduction of water flux due to the decreasing value of pressure head needed to maintain the limiting value of $H = H_{lim}$. It shows that the limiting value $C_{lim}$ can be an important parameter to determine changes in the combined water and osmotic stress in low concentration situations, suggesting it requires more investigation.
- Soil hydraulic properties, root length density, initial concentration and potential transpiration are factors that change the time that the concentration at the root surface starts to decrease and the time that the active uptake is maximum.

# Conclusions

- Quantities that require a careful parameterization are: $\theta_r$, $\theta_s$, $\alpha$, $I_m$ and $K_m$, affecting strongly the solute concentration at the root surface at completion of simulation, $\theta_s$ affecting the time at wich limiting values of solute concentration are reached, and $n$ which strongly affects all selected predictions, mainly $h_\pi$.
- The model showed to be able to quantify the active and passive contributions to the solute uptake, which can be used to distinguish osmotic and ionic stressors in further works.
- The proposed model uses an implicit scheme for the numerical solution of the convection-dispersion, including variable space steps and diffusion coefficients. A more detailed investigation of stability issues for this kind of model would benefit its applicability and is suggested as a future work.