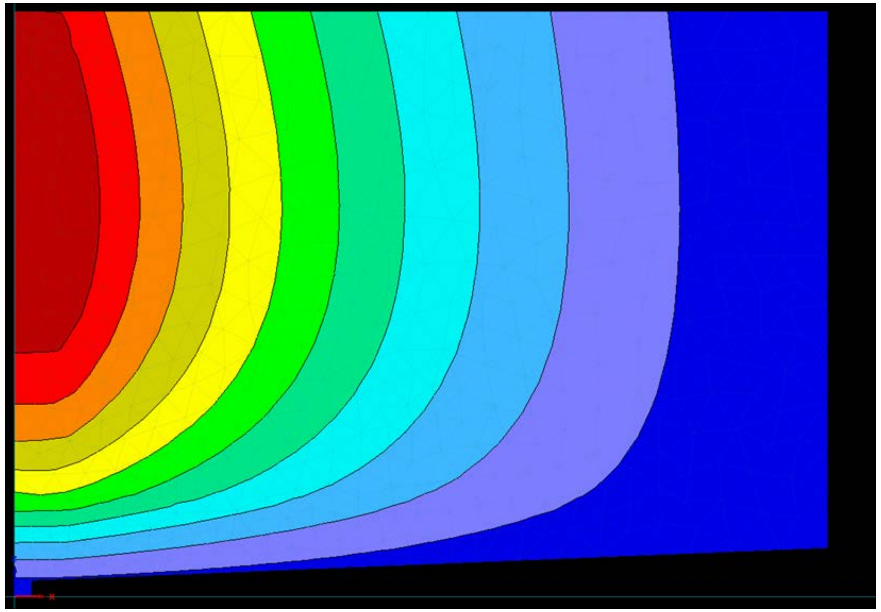
Modeling nitrogen transport, uptake and transformation in the root zone with HYDRUS (2D/3D)



The 13th Dahlia Greidinger International Symposium 2019

Thomas Groenveld*[a,b], Yair Y. Kohn[a], Amir Argaman[c] and Naftali Lazarovitch[b]

[a] Central and Northern Arava Research and Development, Arava Sapir, Israel *tomsadehyarok@gmail.com

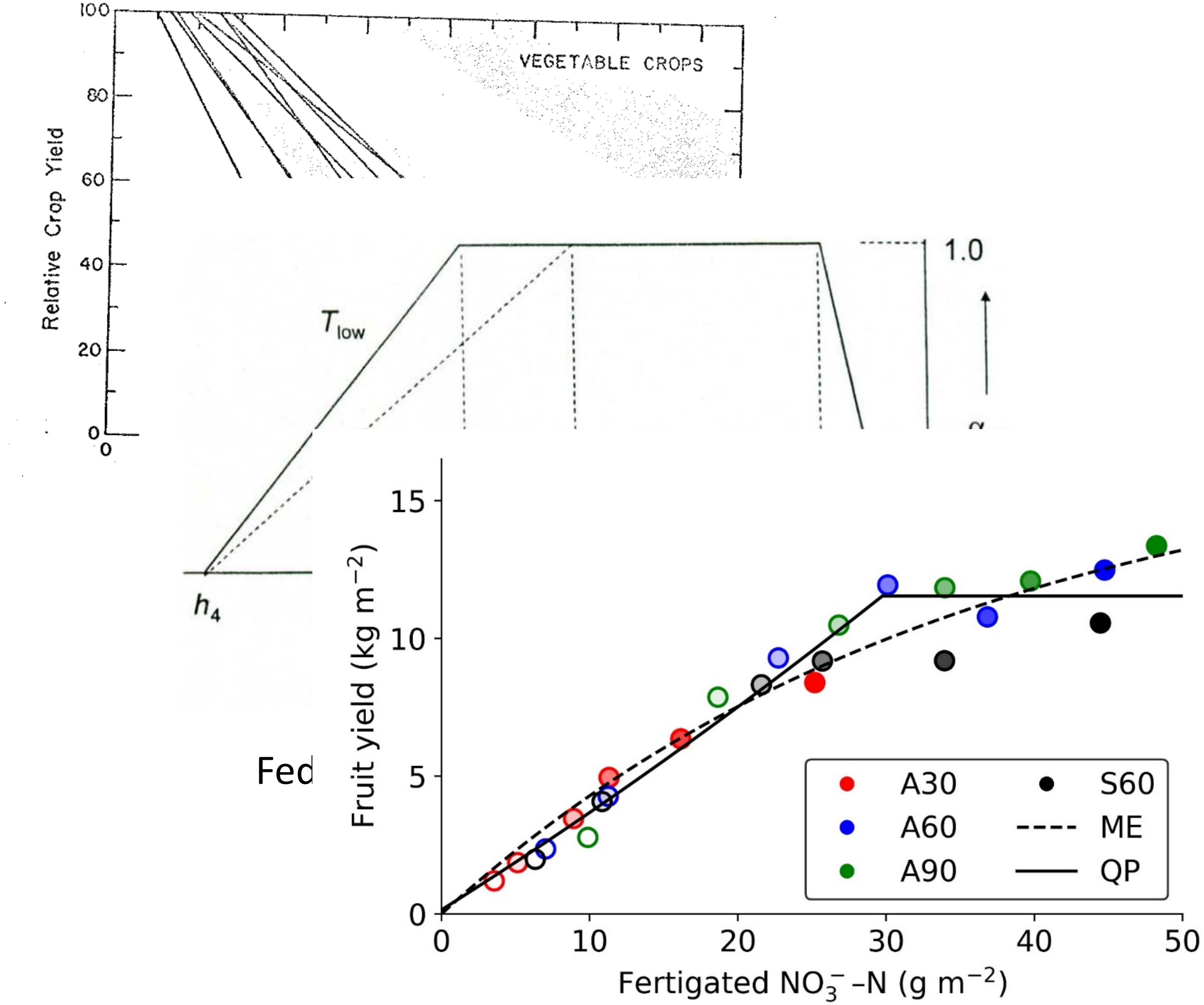
[b] French Associates Institute for Agriculture and Biotechnology of Drylands, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel

[c] Utrecht University, Utrecht, Netherlands

atmosphere

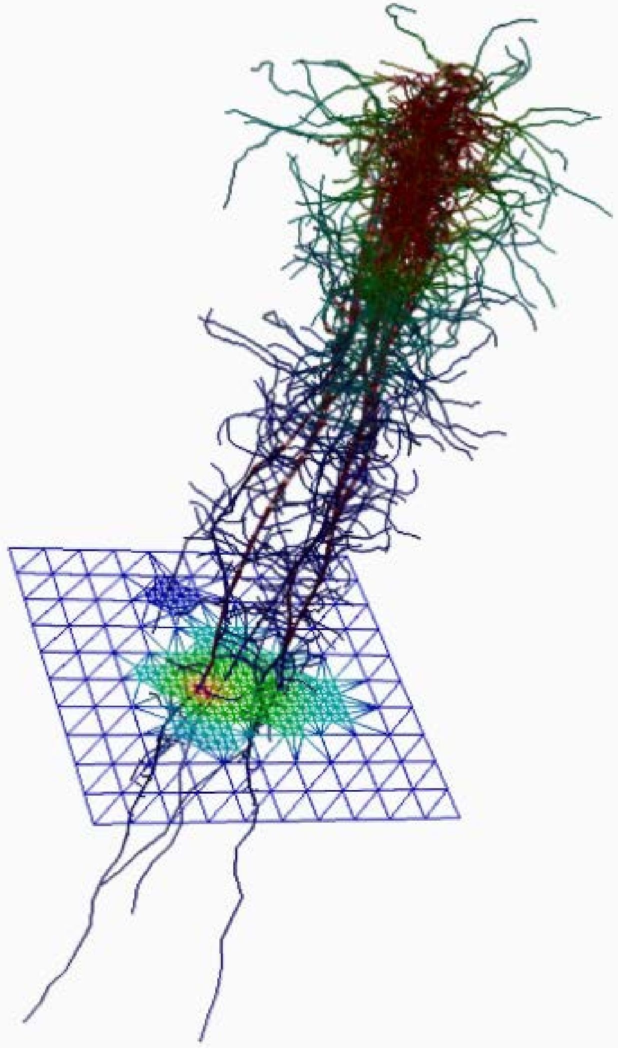
plant

soil



Mitscherlich Exponential (ME)

Quadratic Plateau (QM)



R-SWMS

Objective

To describe the flow of water and transport of nitrogen in the root zone

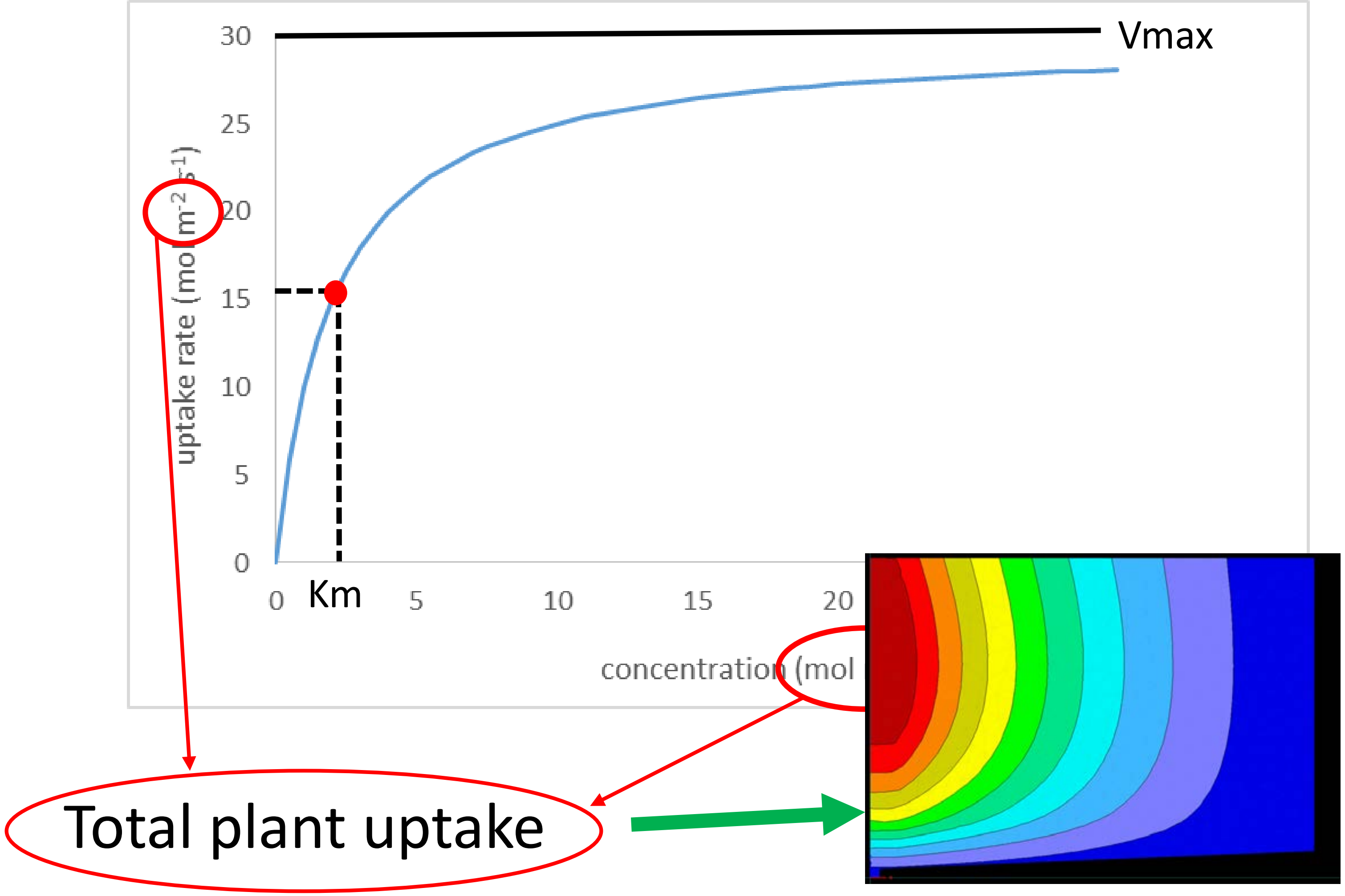
on the basis of measured time variable boundary conditions.

HYDRUS (2D/3D)

- Water flow in the unsaturated zone – Richards’ equation
- Solute transport- convection dispersion equation
- Transpiration reduction due to water stress- van Genuchten S-shape
- Chemical phase change - first order decay reaction
- Active, passive and compensated nitrate uptake
- Root growth function

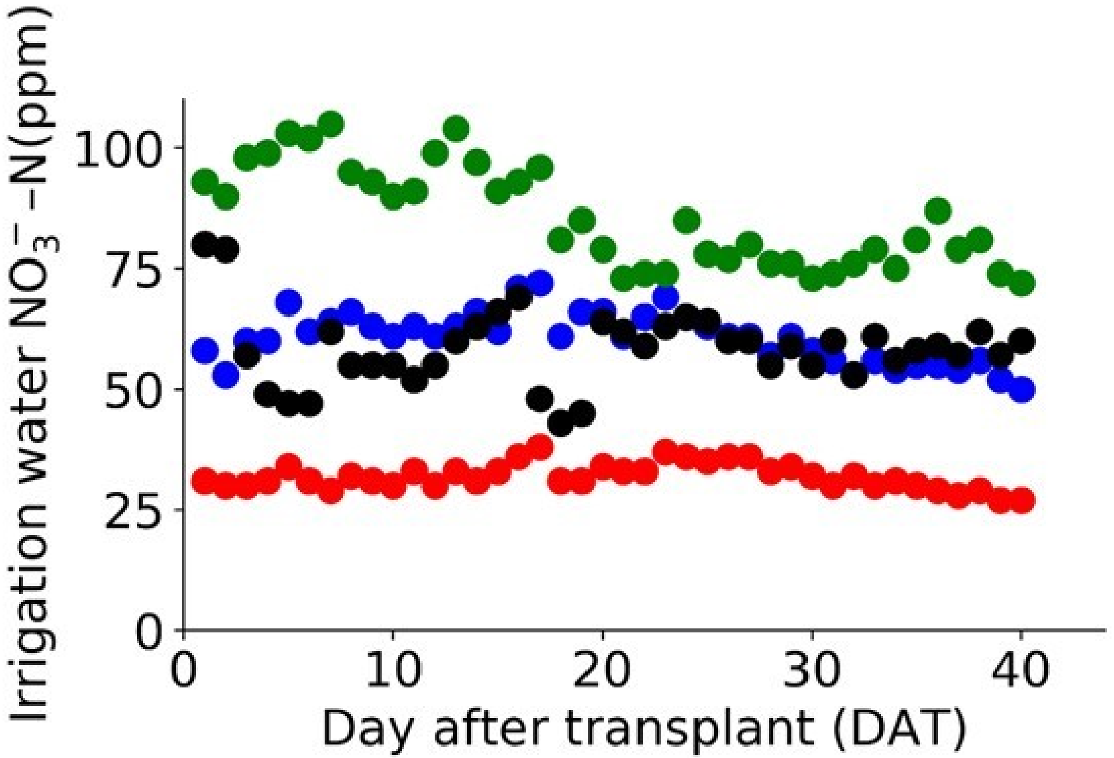
- Used frequently in modeling nitrogen flow and uptake

Modeling active uptake

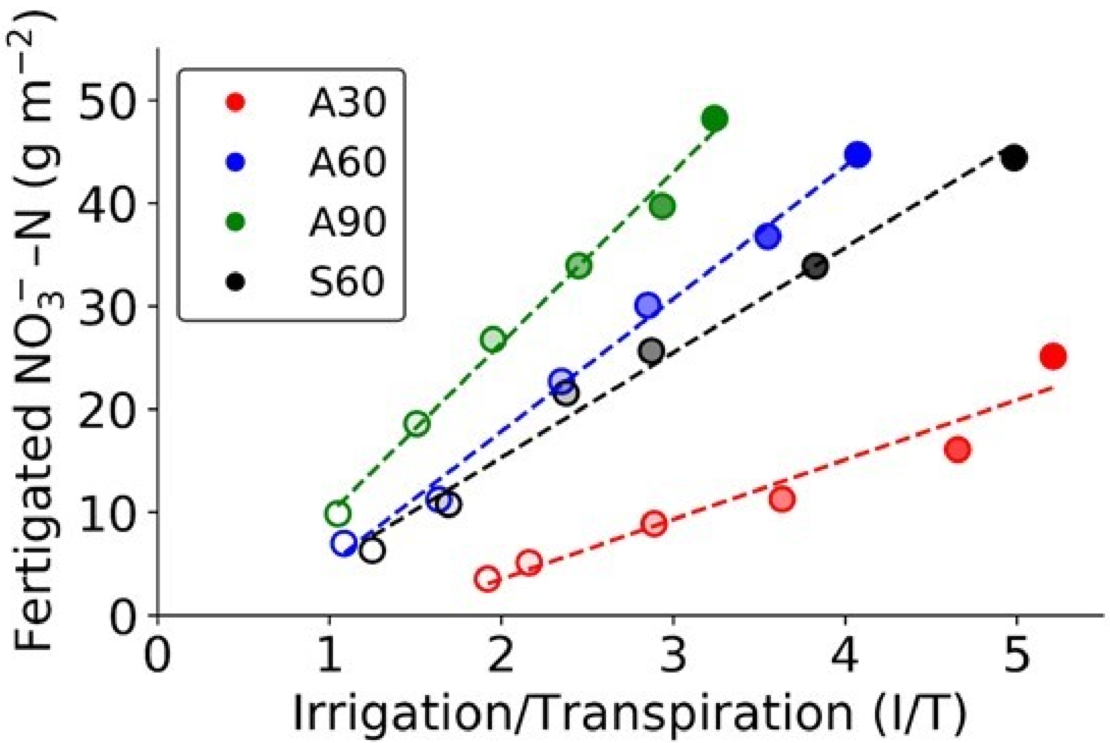


- Vmax - max uptake rate
- Km - concentration 50% Vmax
- Cmin - required concentration

- Root area
- Root spacing
- Growth rate



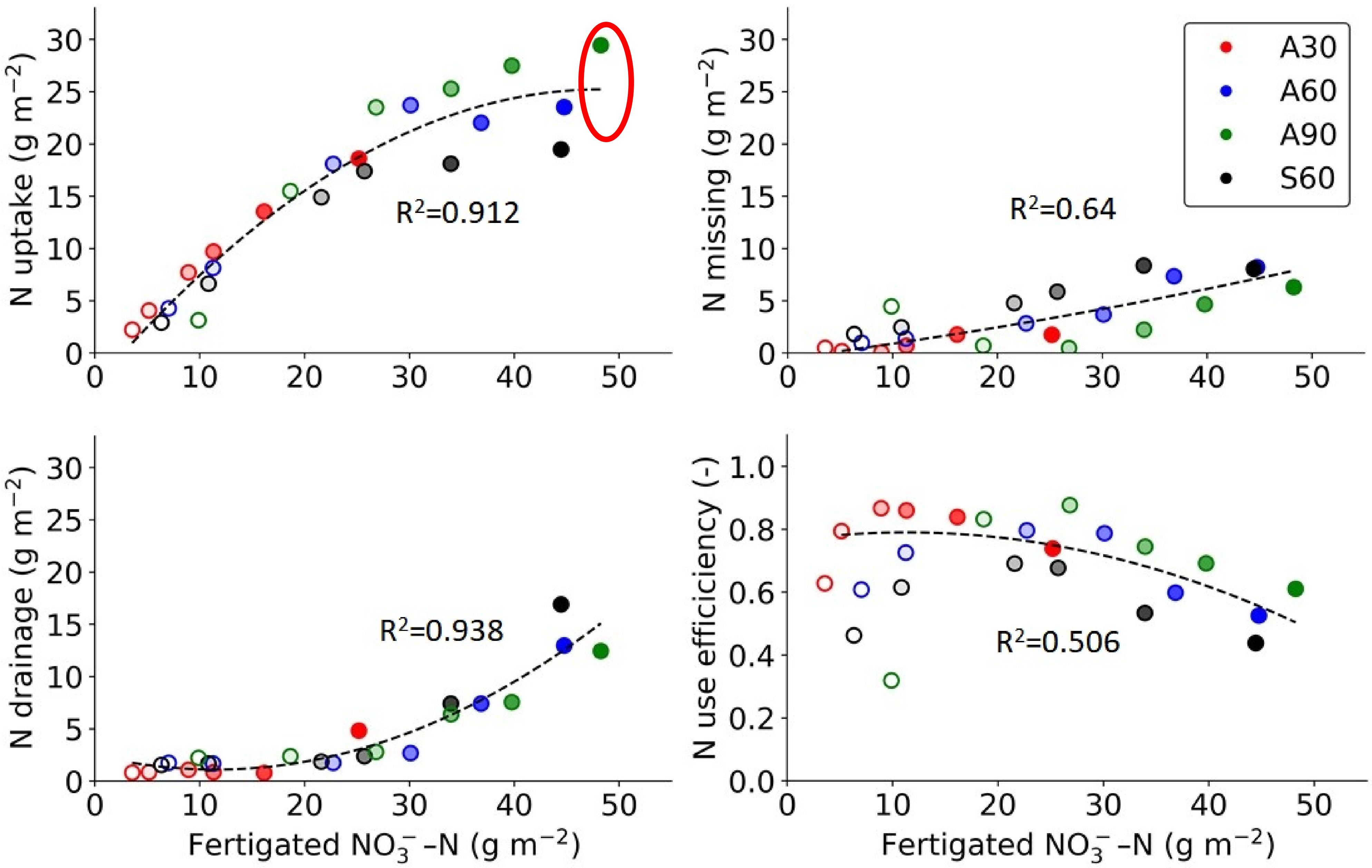
Irrigation water NO_3^- –N(ppm)
100
75
50
25
0
0
10
20
30
40
Day after transplant (DAT)



Fertigated NO_3^- –N (g m^{-2})
A30
A60
A90
S60
50
40
30
20
10
0
0
1
2
3
4
5
Irrigation/Transpiration (I/T)

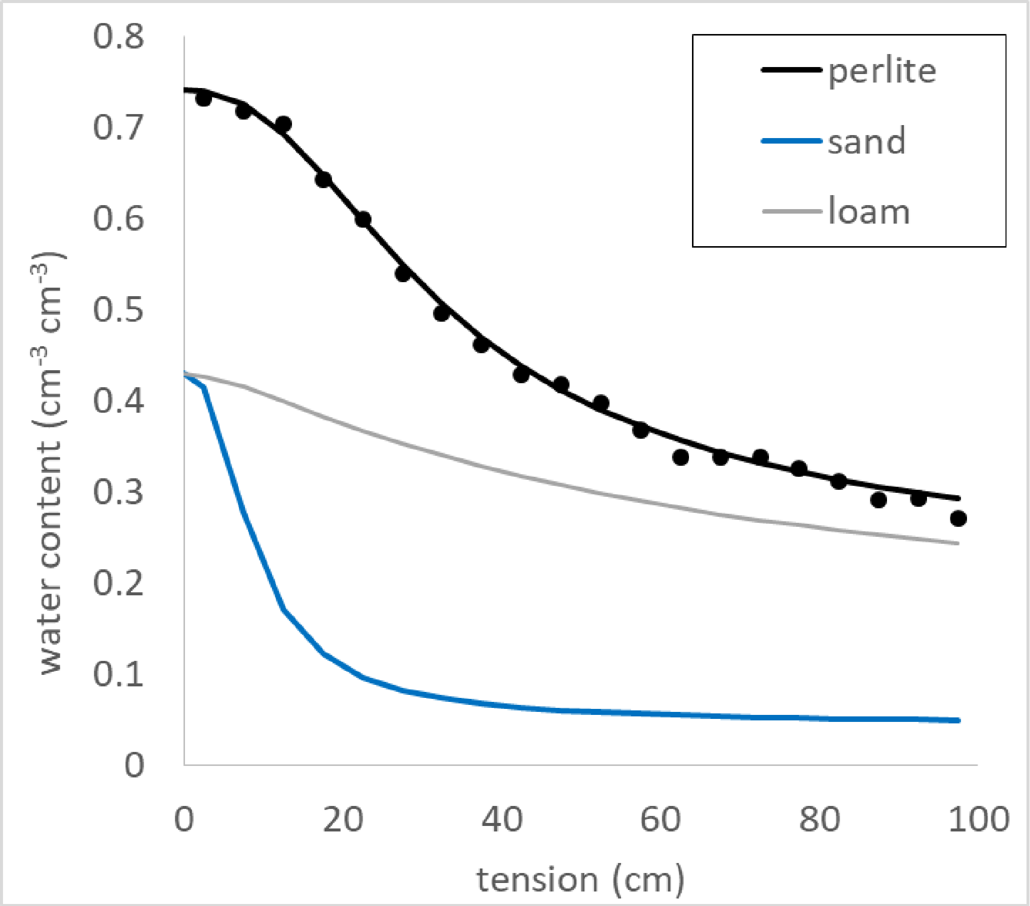
Experimental Setup- Fishfarm

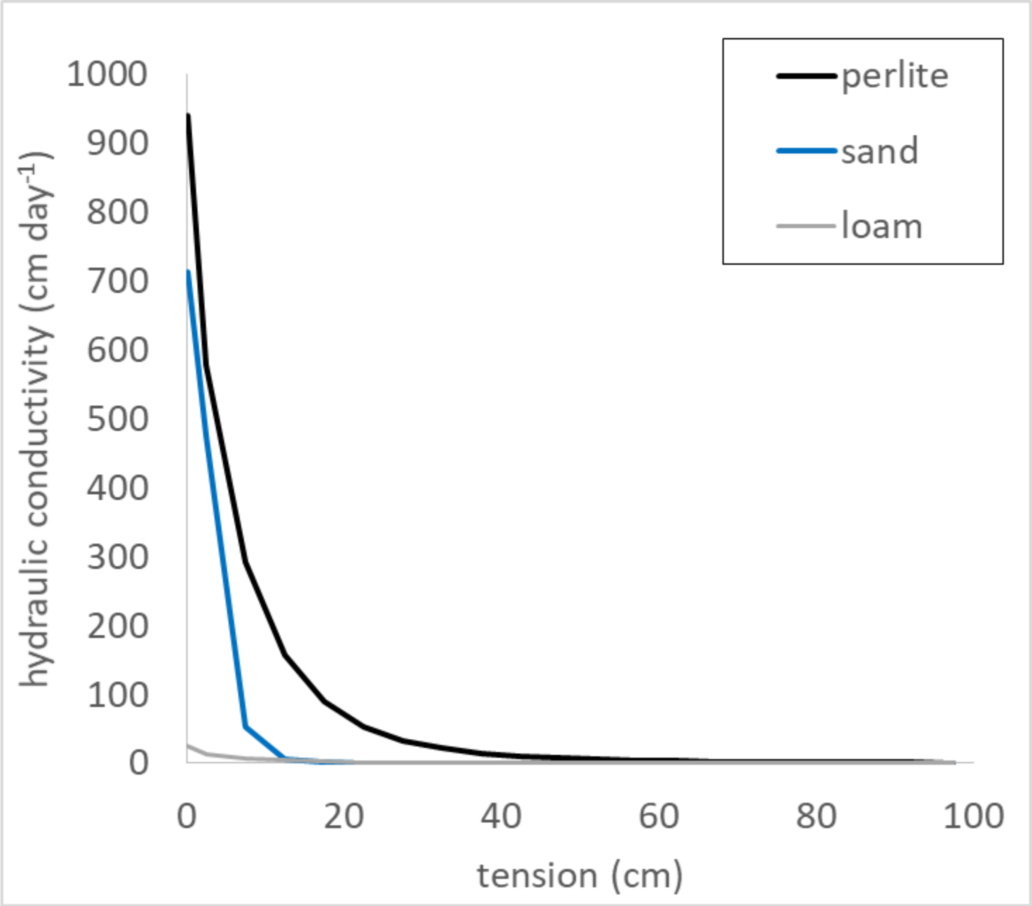
Experimental Setup- Greenhouse



N uptake (g m^{-2})
R^2=0.912
N missing (g m^{-2})
R^2=0.64
A30
A60
A90
S60
N drainage (g m^{-2})
R^2=0.938
N use efficiency (-)
R^2=0.506
Fertigated NO_3^--N (g m^{-2})
Fertigated NO_3^--N (g m^{-2})

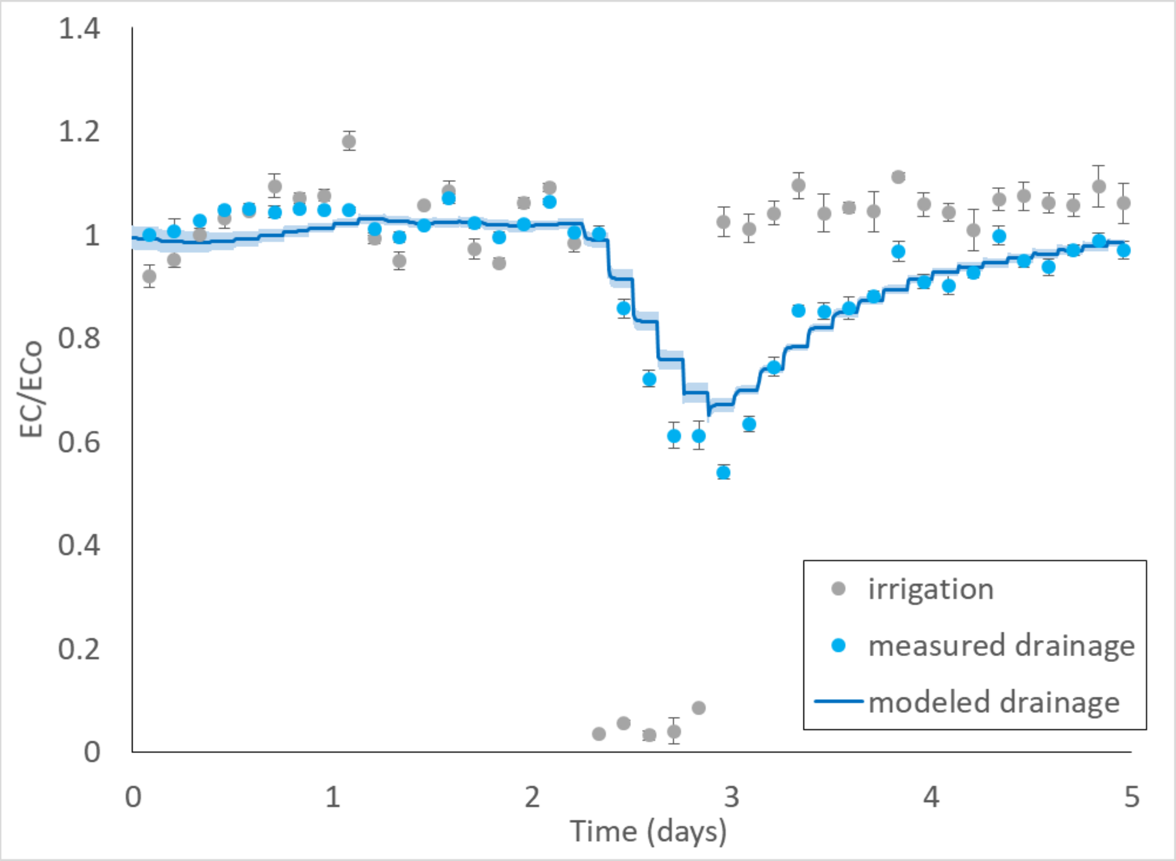
Perlite hydraulic properties





Ks: 943 cm day-1, thetaS: 0.74, thetaR: 0.214, alfa: 0.0388, n: 2.405

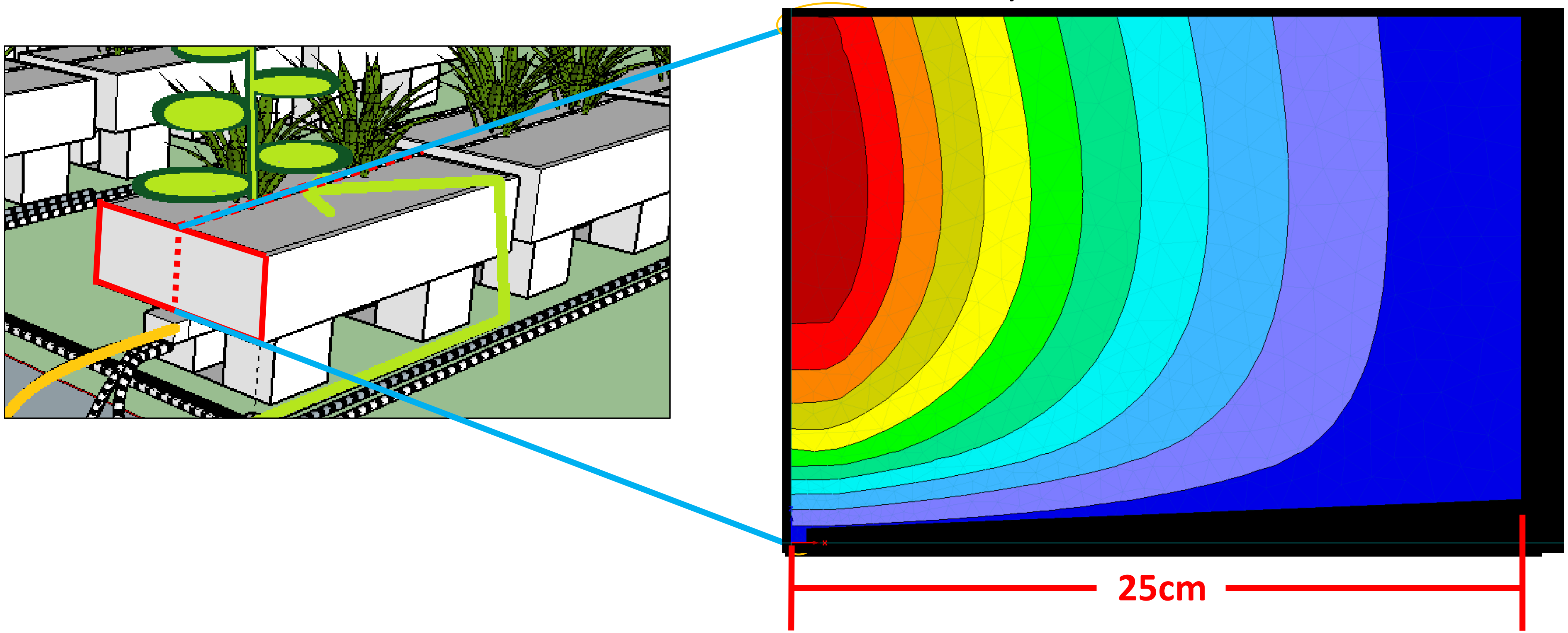
Inverse calculation of dispersivity



dispL:7.8 , dispT: 0.01

Domain properties: root density distribution

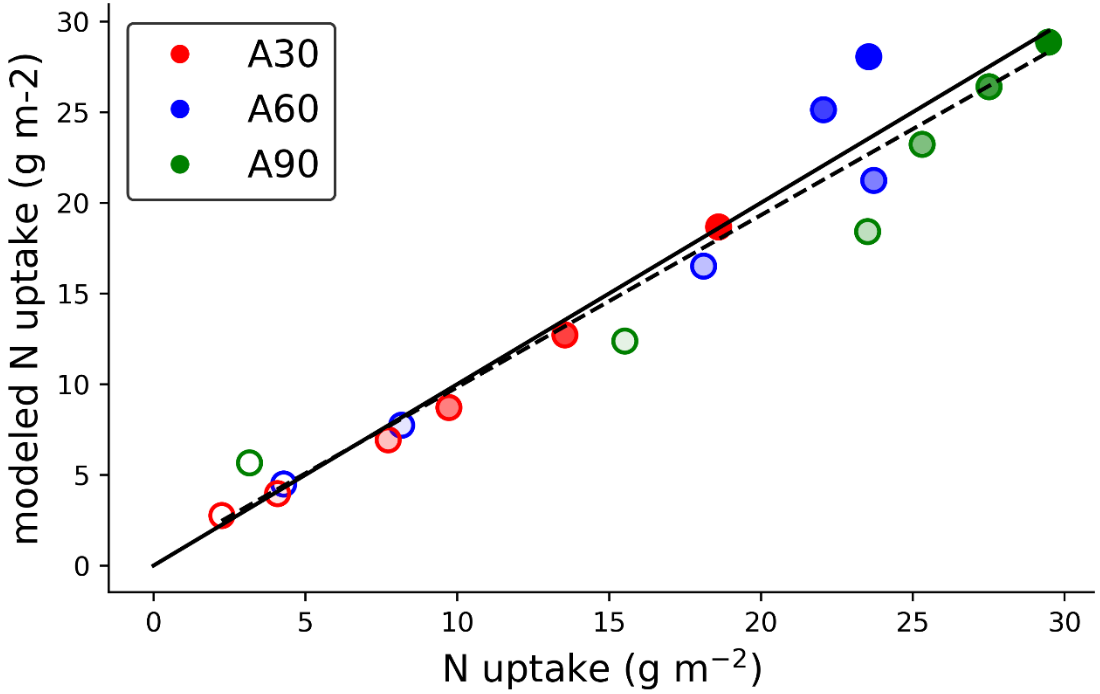
Boundary conditions

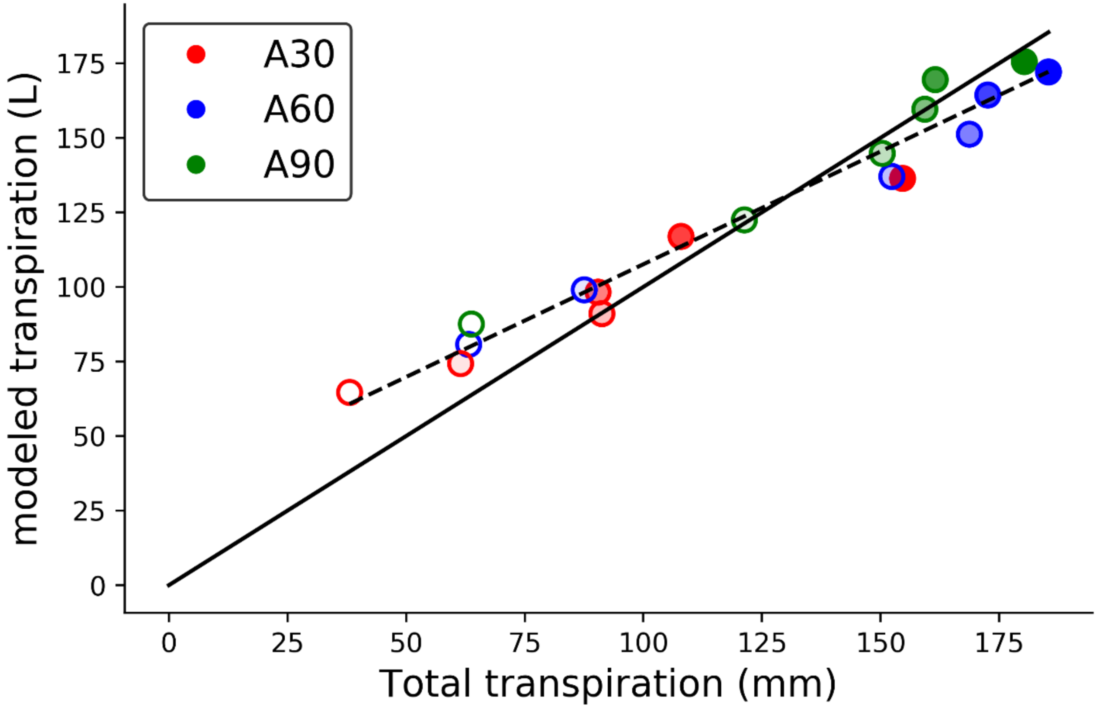


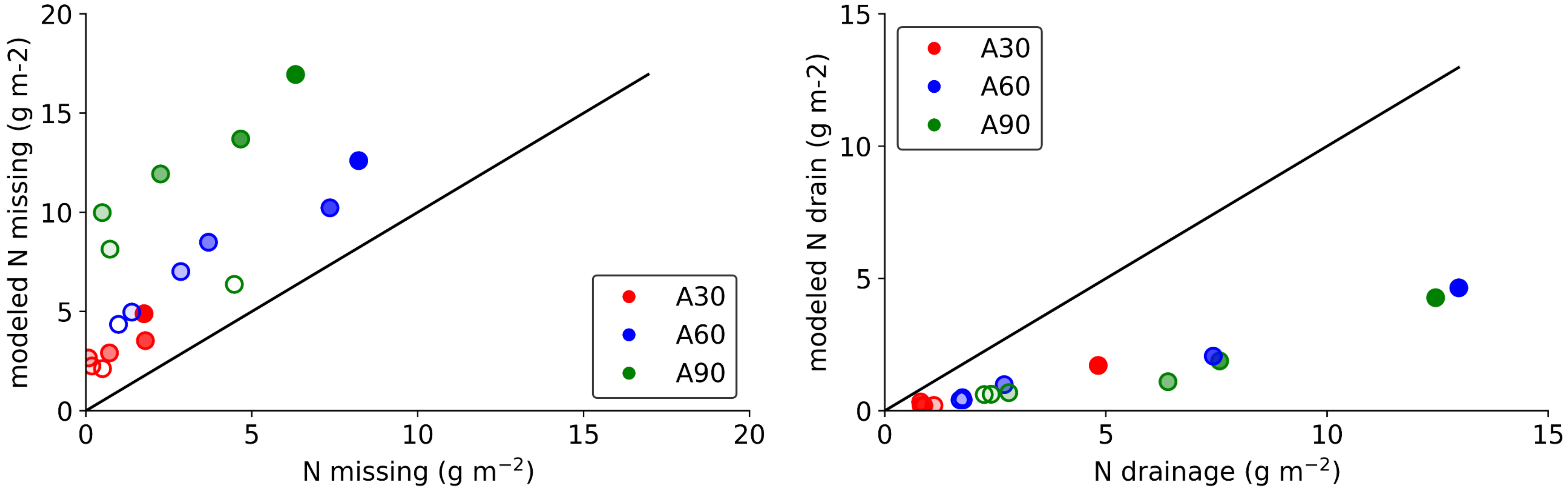
$$R_p(t+1) = R_p(t)\left(\frac{T_a}{T_p}\right)$$

$$T_p(t+1) = T_p(t)\left(\frac{R_a}{R_p}\right)$$

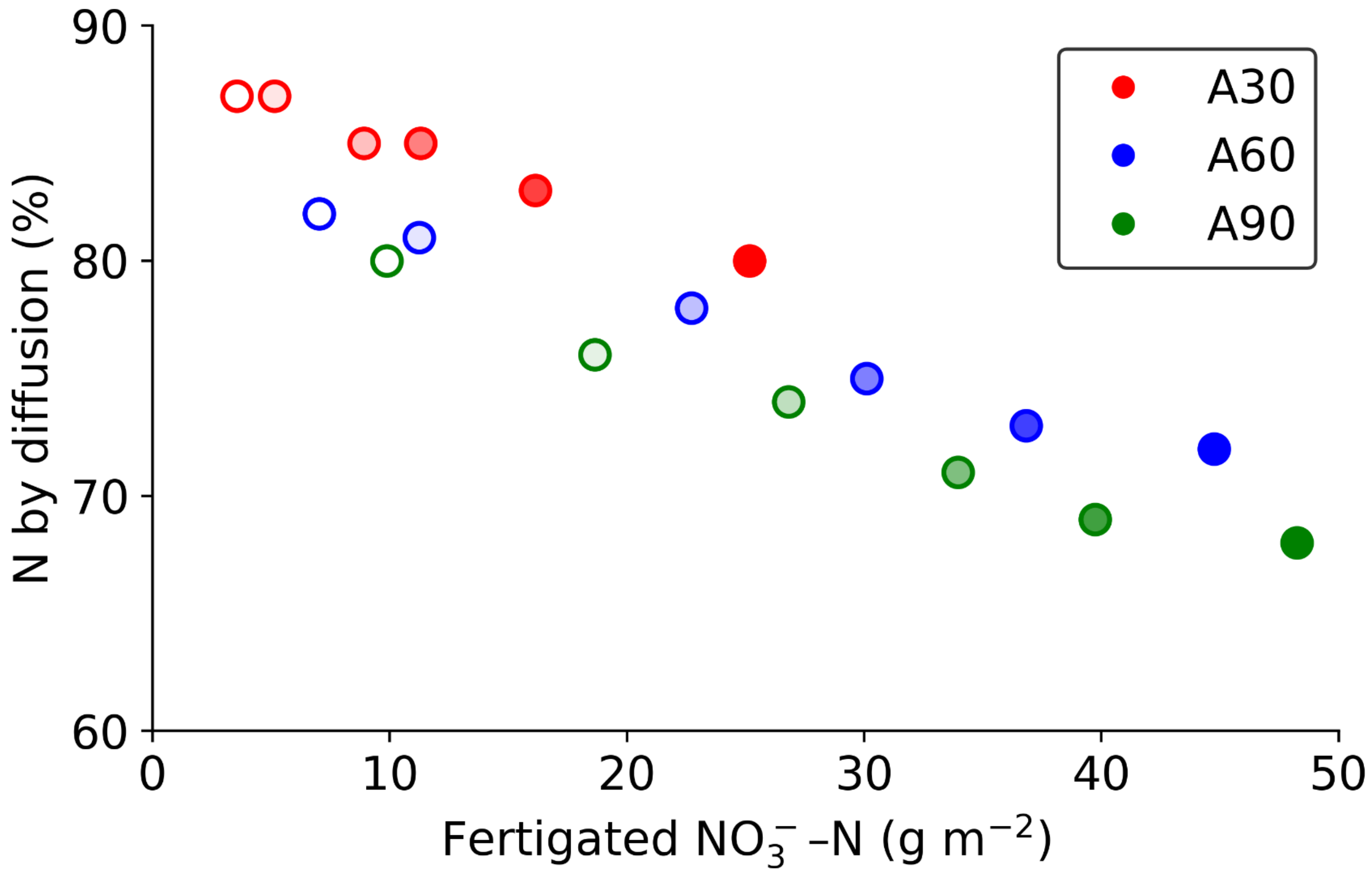
R_p: potential nitrogen uptake
R_a: actual nitrogen uptake
T_p: potential transpiration
T_a: actual transpiration







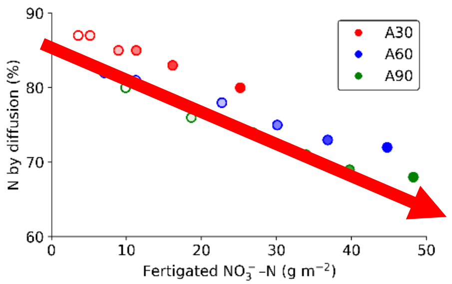
modeled N missing (g m-2)
N missing (g m^{-2})
0
5
10
15
20
A30
A60
A90
modeled N drain (g m-2)
N drainage (g m^{-2})
0
5
10
15
A30
A60
A90



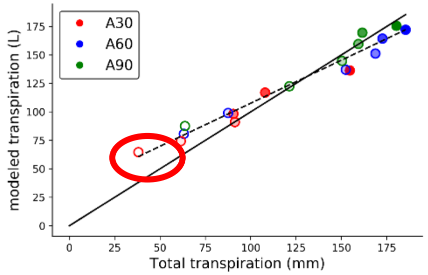
A30
A60
A90
N by diffusion (%)
90
80
70
60
0
10
20
30
40
50
Fertigated NO_3^-–N (g m^{-2})

Conclusions

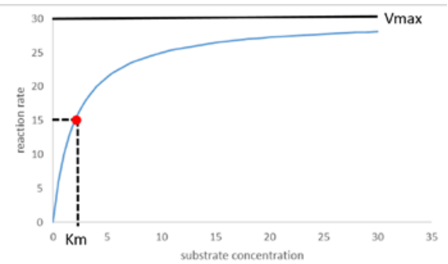
Under lower N fertigation, transport to the root surface by diffusion increases, as does the gradient against which active N uptake must take place.



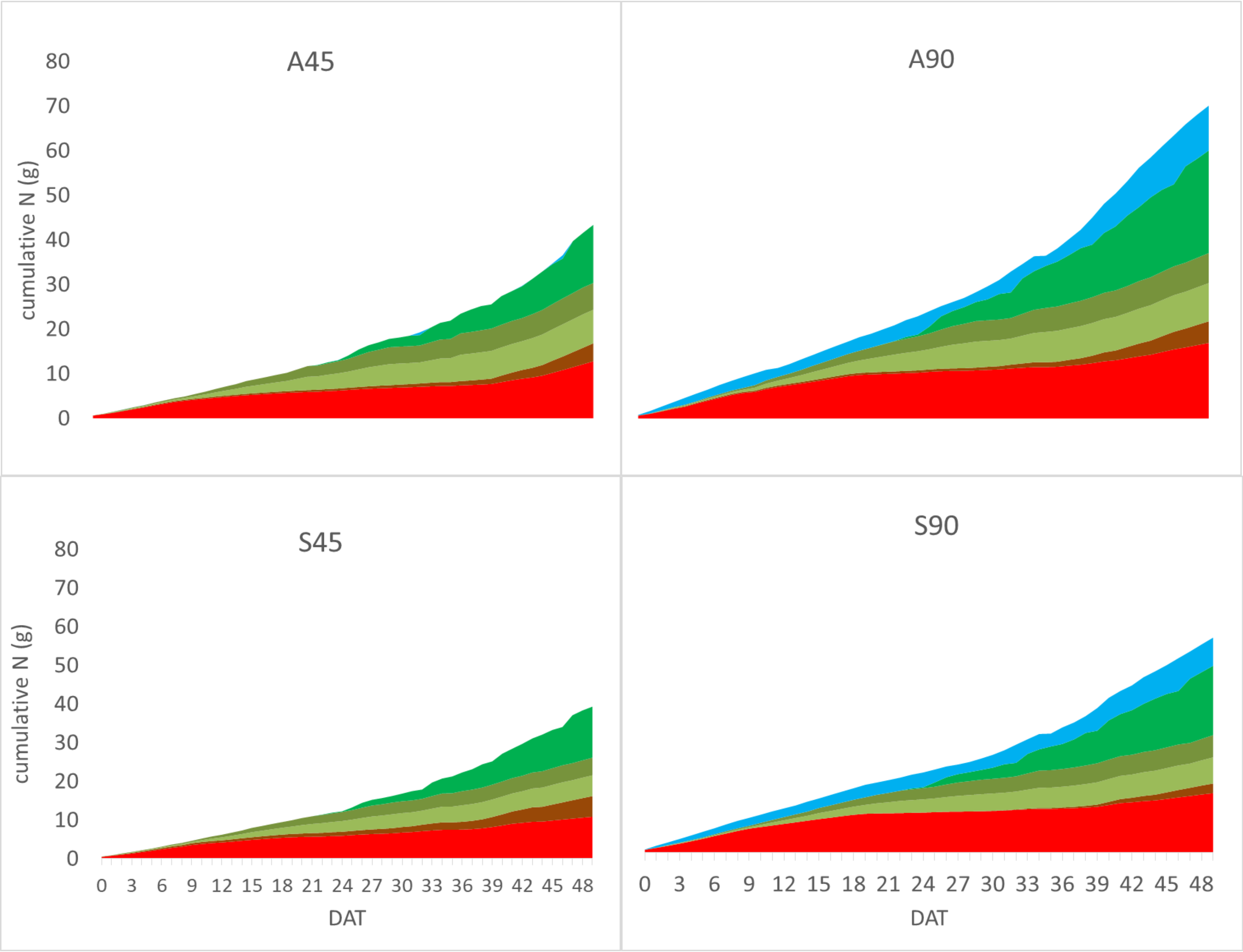
The effects of salinity are still apparent in reduced transpiration, even for plants that are under severe nitrogen stress.



It is possible to describe active uptake without precise measurement of root length or area in HYDRUS (2D/3D)



Questions ?



A45
A90
S45
S90
cumulative N (g)
cumulative N (g)
80
70
60
50
40
30
20
10
0
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48
DAT
DAT