



MODELING TOMATO ROOT WATER UPTAKE

INFLUENCE OF SECONDARY GROWTH, HYDROPHOBIC BARRIERS
AND DEVELOPMENTAL ANATOMY ON ROOT HYDRAULIC PROPERTIES

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 UCLouvain



European Research Council
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 SEB 2025



**GUILLAUME
LOBET**

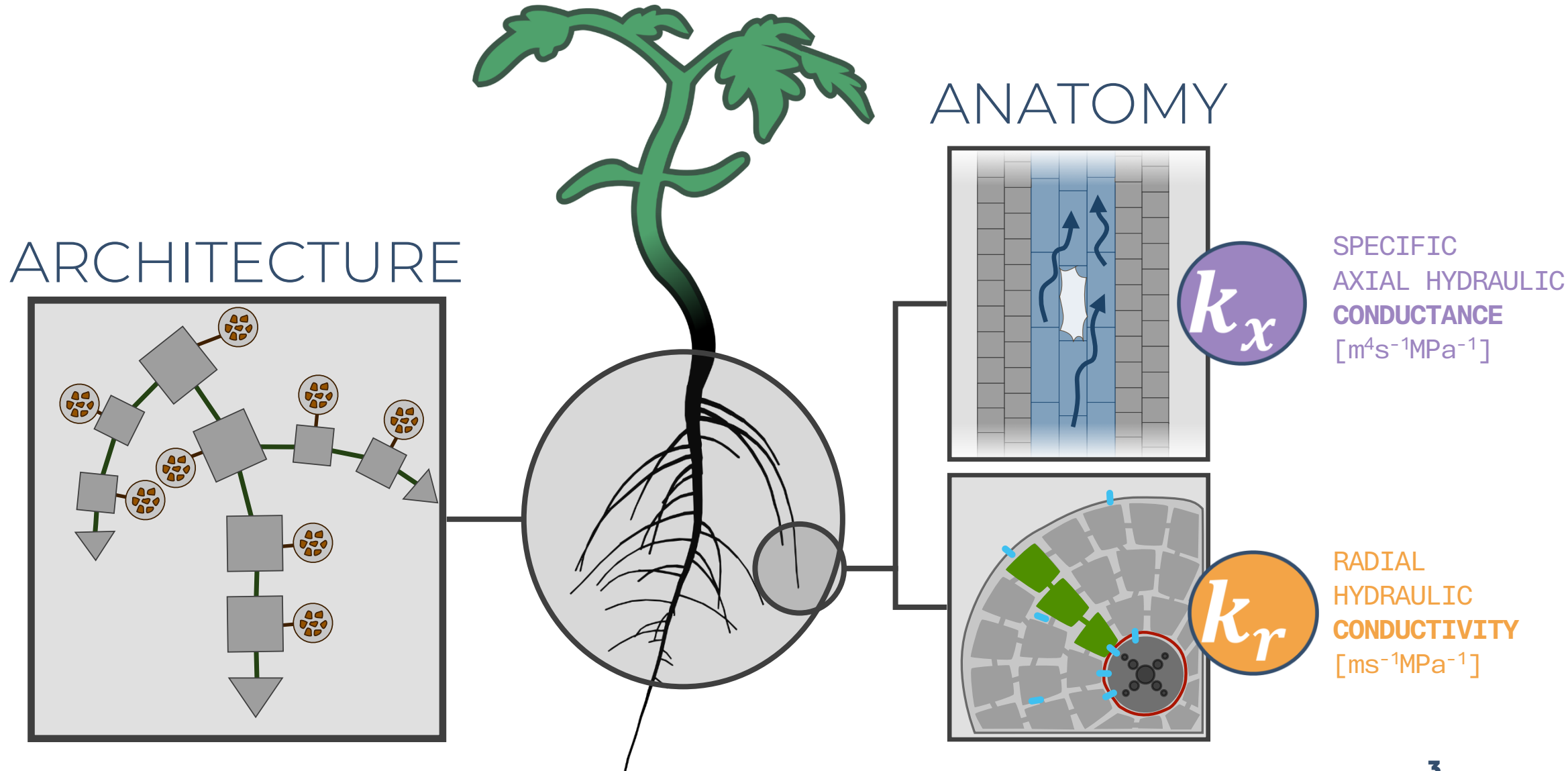


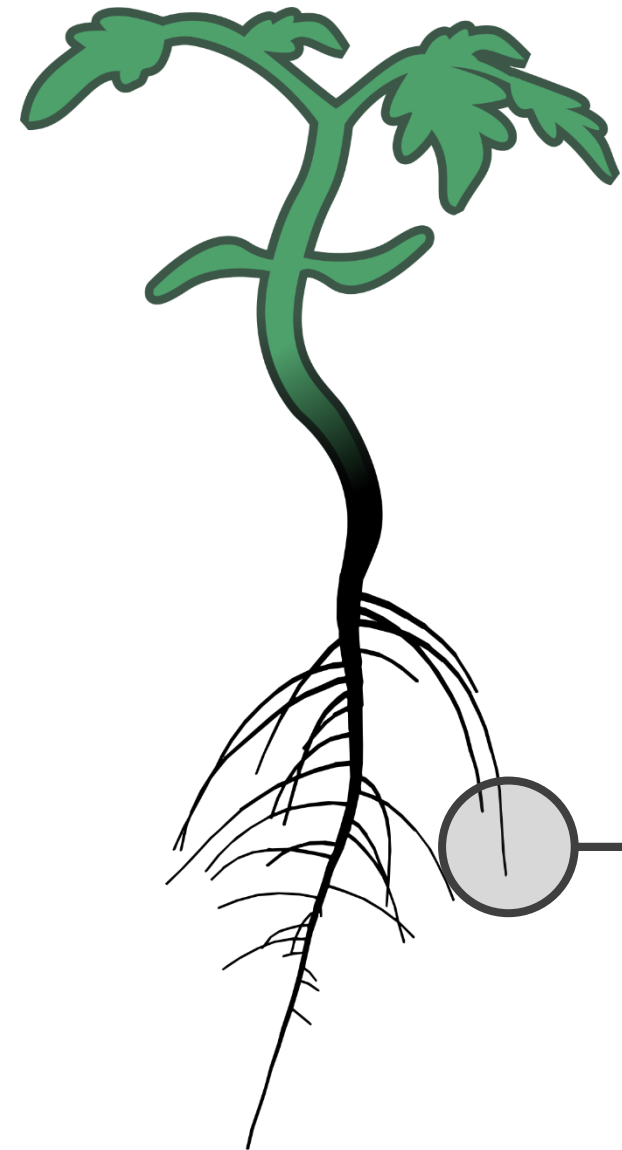
**XAVIER
DRAYE**



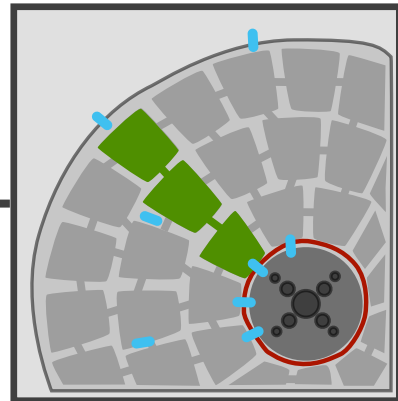
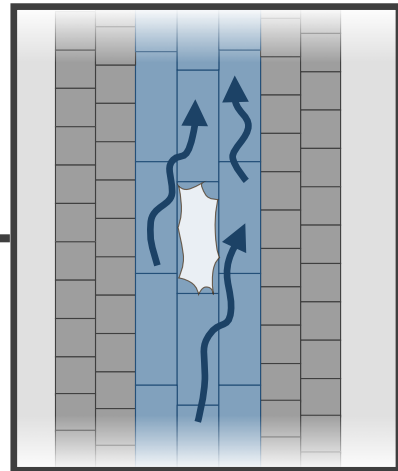
**VALENTIN
COUVREUR**

ROOT WATER UPTAKE



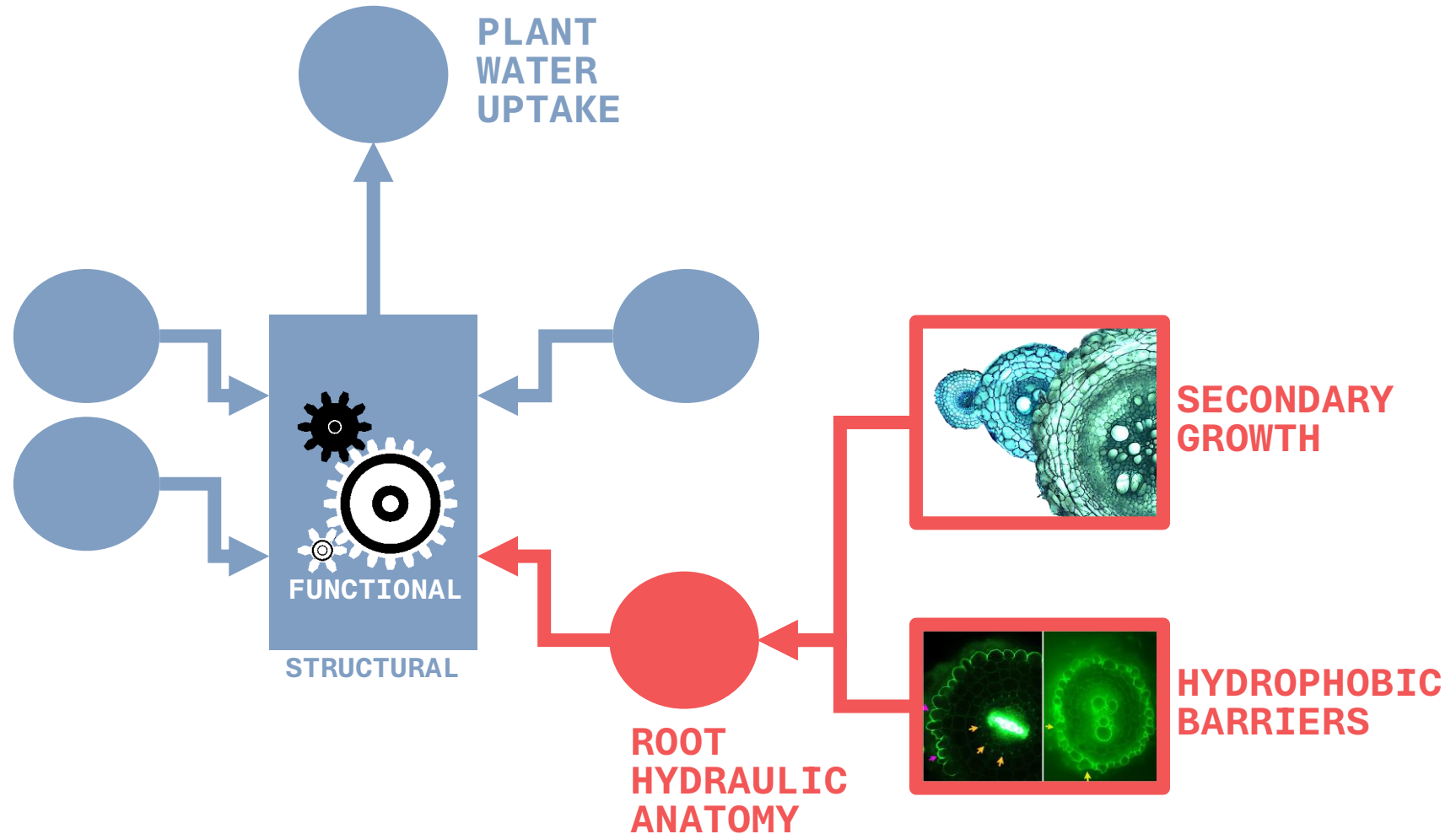


ANATOMY

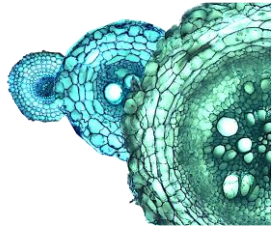


- DEFINES LOCAL WATER UPTAKE
- PRESENTS TRAITS OF INTEREST
- HAS PHENOTYPIC DIVERSITY
- **IS UNDER-EVALUATED IN PHENOTYPING !**
- **DIFFICULT TO ACCESS IN HIGH-THROUGHPUT**

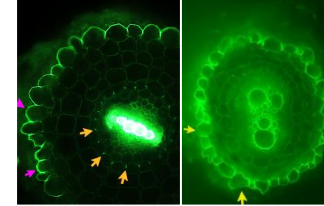
WE USE **FUNCTIONAL-STRUCTURAL MODELS** TO REPRESENT PLANT WATER UPTAKE



WE USE **TOMATO** AS PLANT MODEL BECAUSE IT HAS...



SECONDARY GROWTH



SPECIFIC HYDROPHOBIC BARRIERS



COOL PEOPLE WORKING ON THAT

SUPER-INTERESTING GENETIC DIVERSITY



Théo Degand
UCLouvain



Siobhan Brady
UCDavis

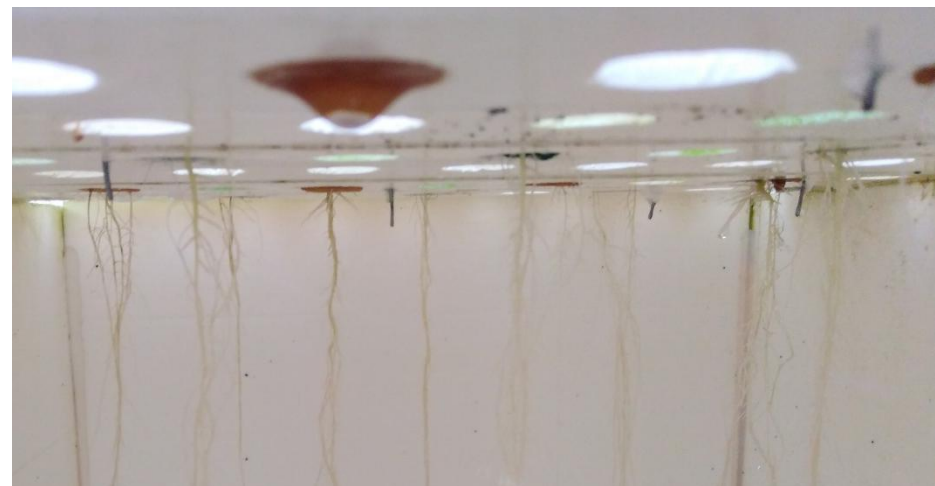
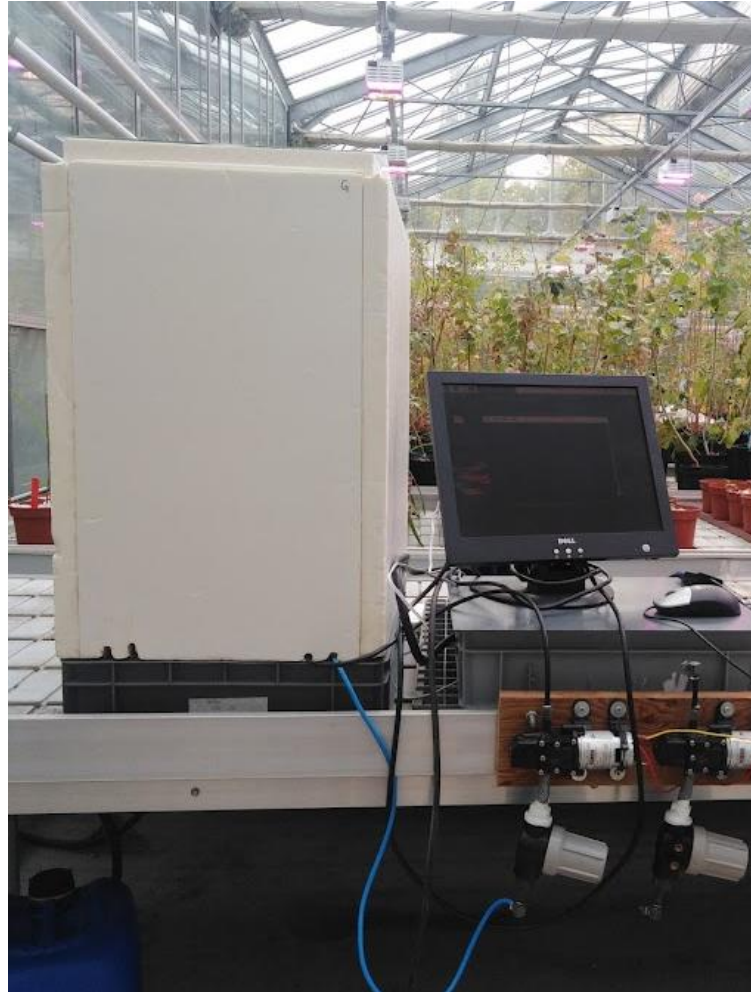


Magdalena Julkowska
Cornell University

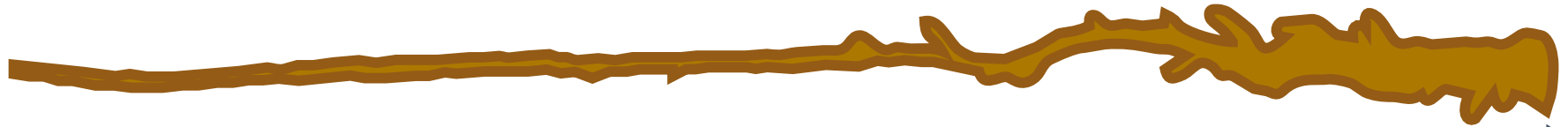


Muriel Quinet
UCLouvain

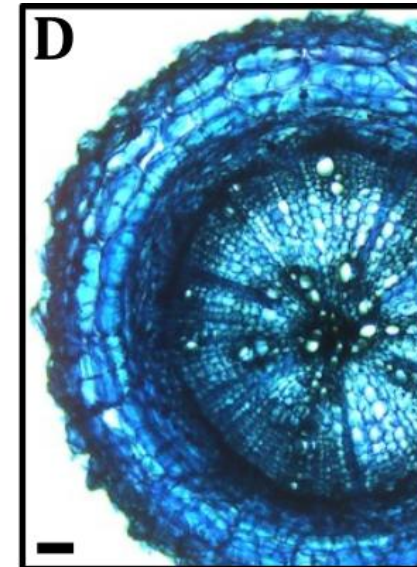
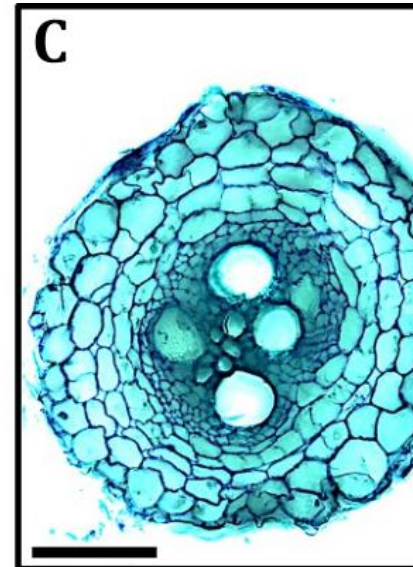
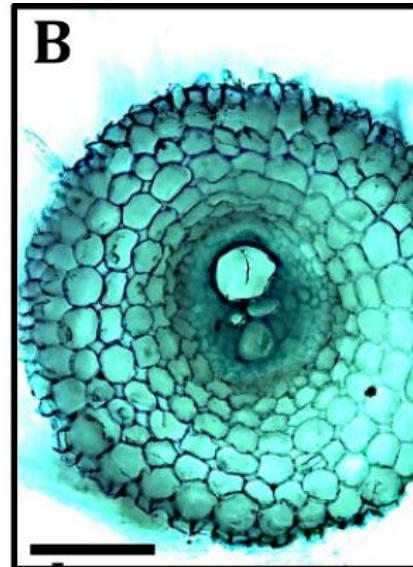
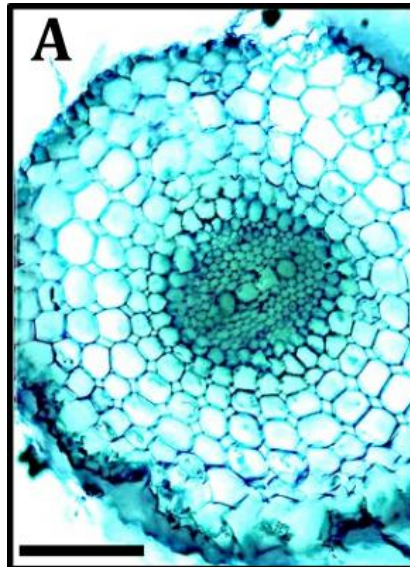
WE GREW **TOMATO** (*Solanum lycopersicum* Moneymaker) **IN AEROPONICS**

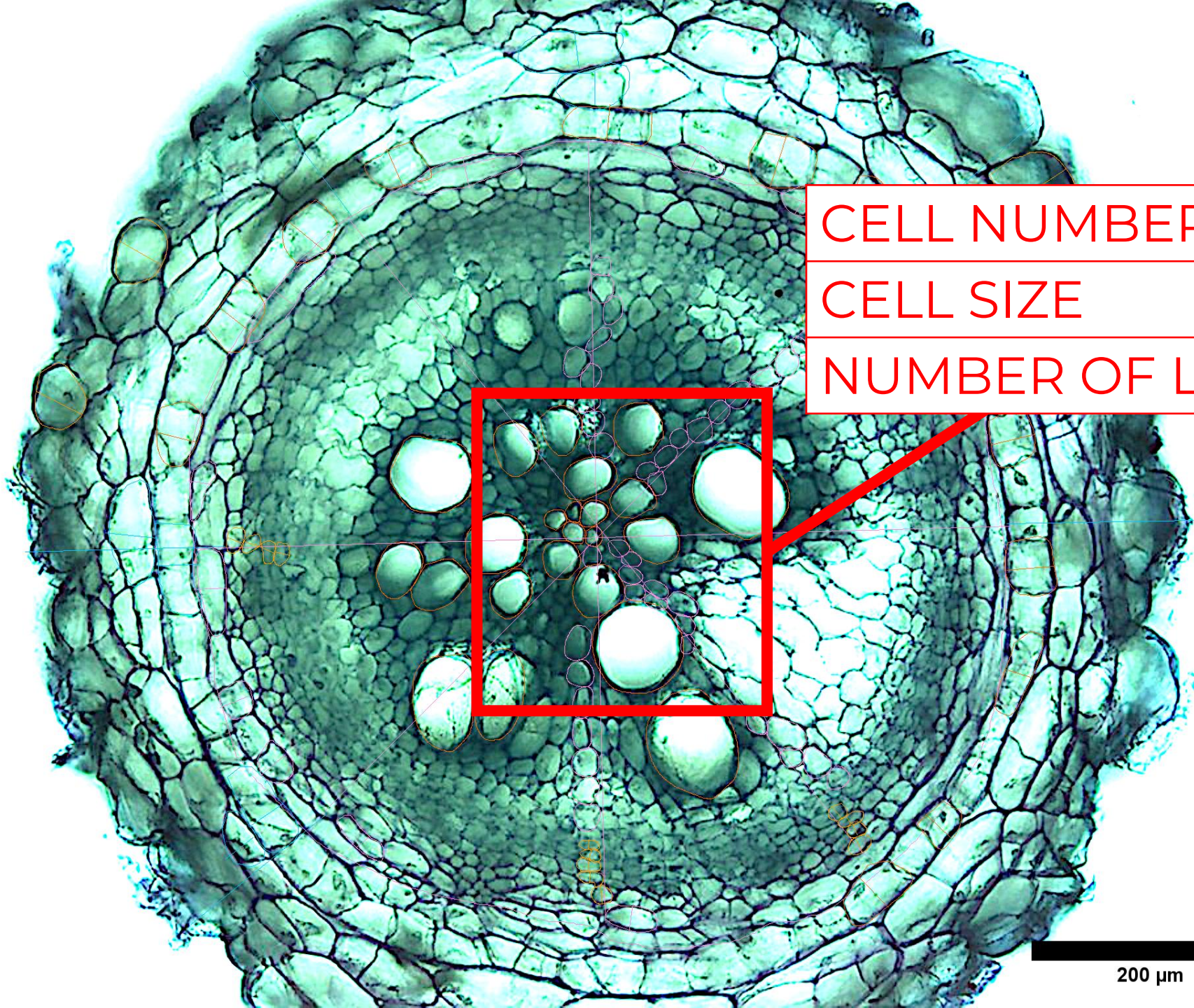


WE QUANTIFIED TOMATO ROOT **ANATOMY**



----->
Tip (0 days) Collar (30 days)





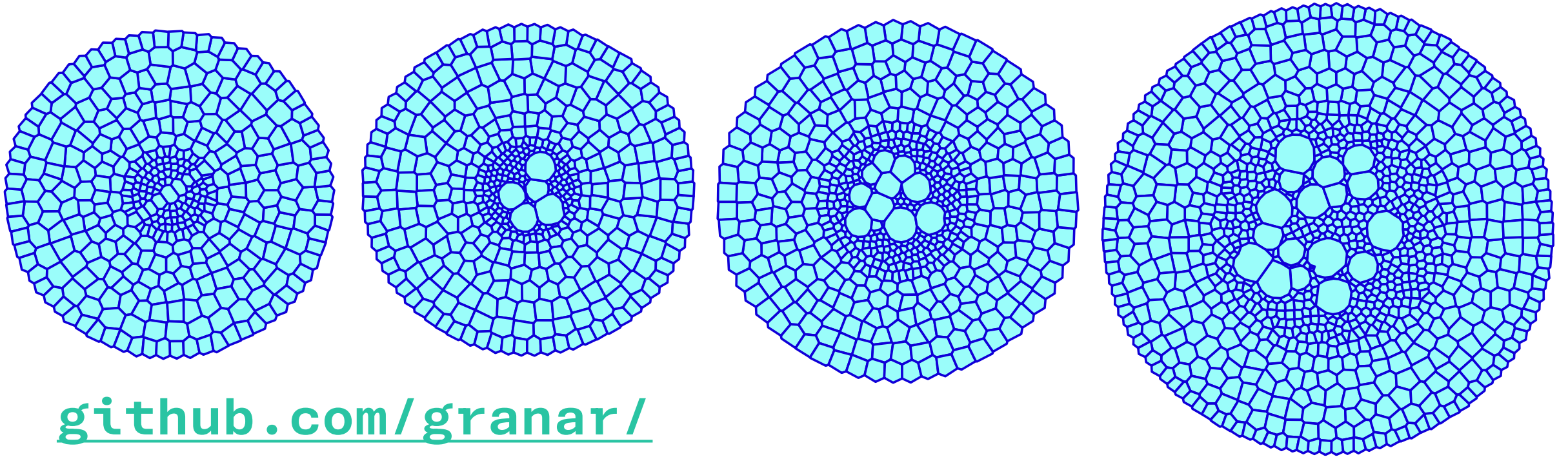
CELL NUMBER

CELL SIZE

NUMBER OF LAYERS

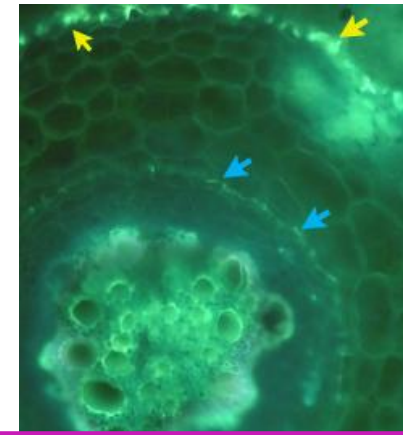
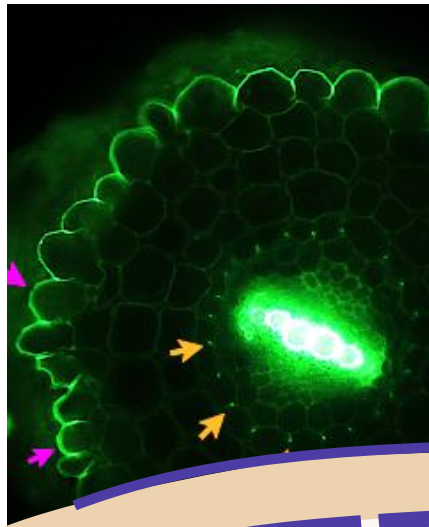
200 μm

WE UPDATED
A GENERATOR OF ROOT ANATOMY
TO INCLUDE **SECONDARY GROWTH**



github.com/granar/

WE MONITORED **HYDROPHOBIC BARRIERS**



SUBERIN
LIGNIN

nature plants



Article

<https://doi.org/10.1038/s41477-024-01864-z>

Regulation and function of a **polarly localized lignin barrier in the exodermis**

Received: 31 July 2024

Accepted: 28 October 2024

Published online: 02 December 2024

Concepcion Manzano^{1,2}, Kevin W. Morimoto¹, Lidor Shaar-Moshe^{1,3}, G. Alex Mason¹, Alex Cantó-Pastor¹, Mona Gouran¹, Damien De Bellis^{4,5}, Robertas Ursache^{4,6}, Kaisa Kajala^{1,7}, Neelima Sinha⁸, Julia Bailey-Serres⁹, Niko Geldner⁴, J. Carlos del Pozo² & Siobhan M. Brady^{1,10}

nature plants



Article

<https://doi.org/10.1038/s41477-023-01567-x>

A **suberized exodermis** is required for tomato drought tolerance

Received: 31 January 2023

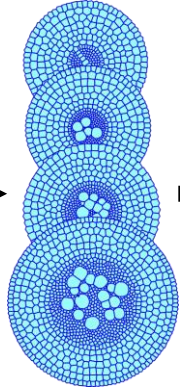
Accepted: 23 October 2023

Published online: 2 January 2024

Check for updates

Alex Cantó-Pastor¹, Kaisa Kajala^{1,2}, Lidor Shaar-Moshe^{1,10}, Concepción Manzano¹, Prakash Timilsena³, Damien De Bellis^{4,5}, Sharon Gray^{1,11}, Julia Holbein⁶, He Yang¹, Sana Mohammad¹, Niba Nirmal¹, Kiran Suresh⁹, Robertas Ursache⁴, G. Alex Mason¹, Mona Gouran¹, Donnelly A. West¹, Alexander T. Borowsky⁹, Kenneth A. Shackel⁹, Neelima Sinha⁷, Julia Bailey-Serres⁹, Niko Geldner⁴, Song Li⁹, Rochus Benni Franke⁹ & Siobhan M. Brady^{1,10}

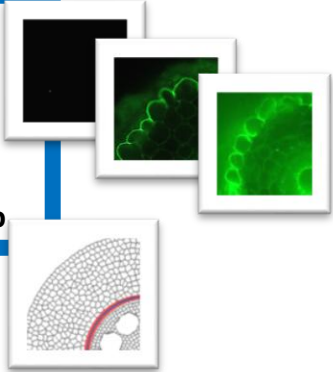
GENERATOR OF ROOT ANATOMY
Heymans et al. 2020



SOLVER OF HYDRAULIC ANATOMY
Couvreur et al. 2018

Hydrophobic depositions :

- **3 tomato :**
 - Ex.CS
 - Ex.CS-Ex.LC
 - Ex.CS-Ex.Sub
- **3 contrasts with En.Sub**



k_r k_x

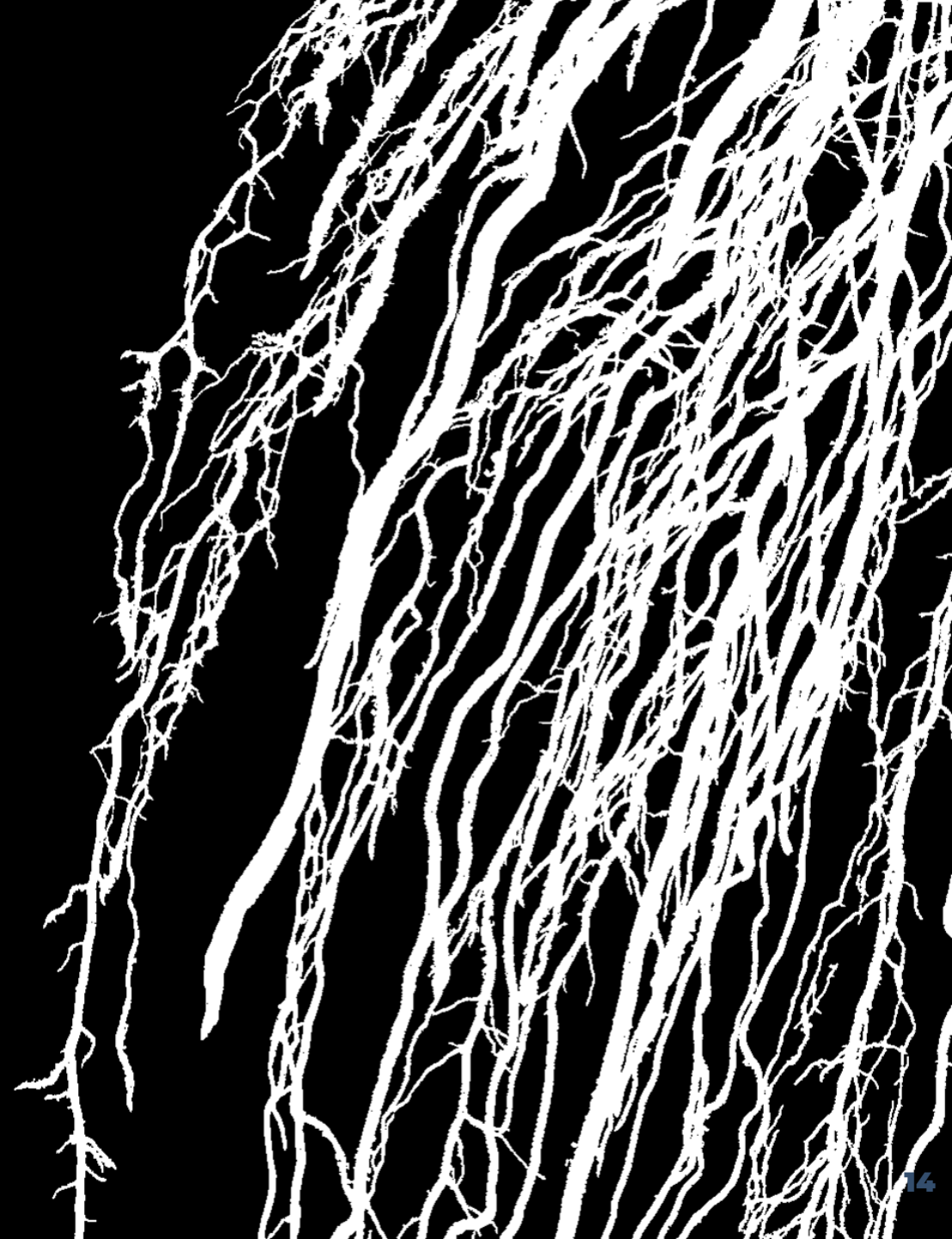
GENERATOR OF ROOT ARCHITECTURE

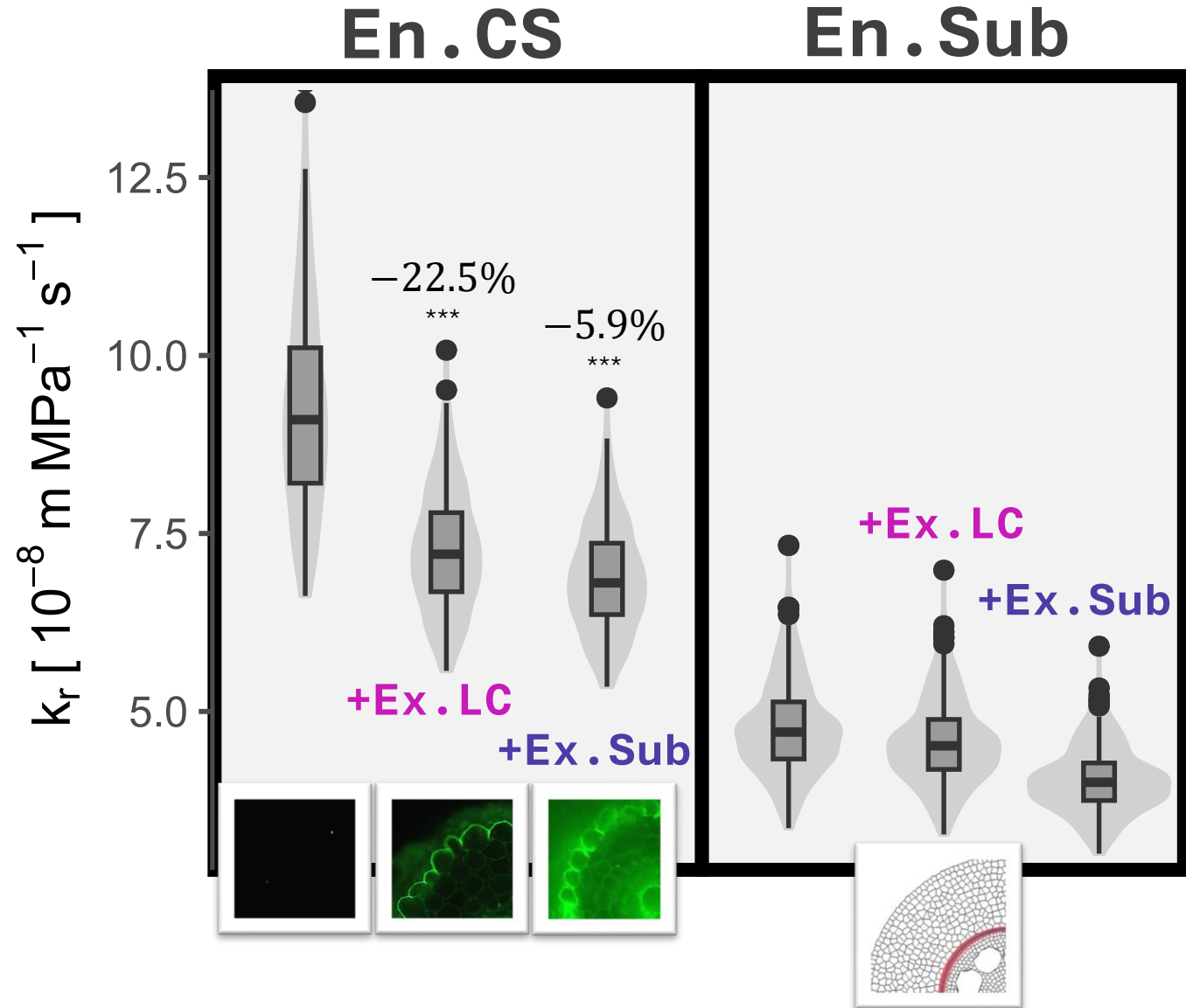


SOLVER OF HYDRAULIC ARCHITECTURE

K_{rs}
 SUF

RESULT 1:
IMPACT OF
**HYDROPHOBIC
BARRIERS**
ON **RADIAL
CONDUCTIVITY**





Lignin cap
decreases k_r

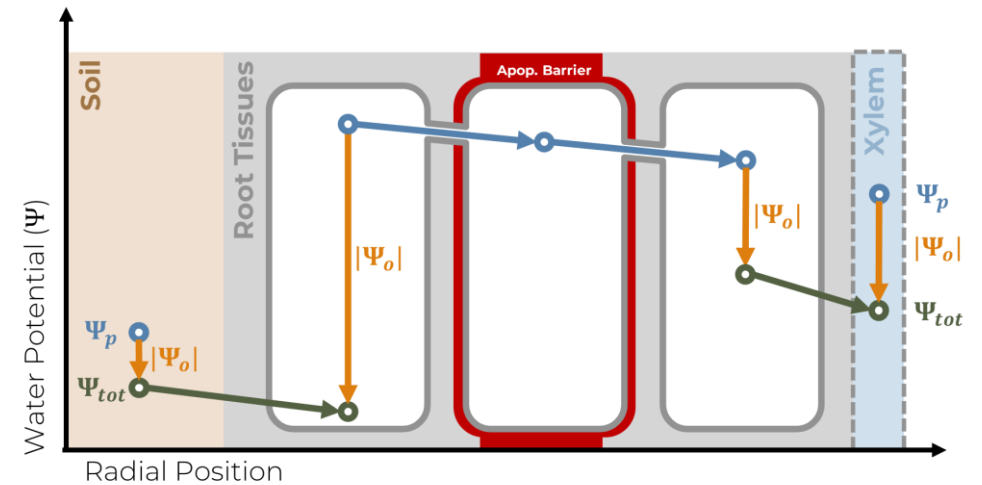
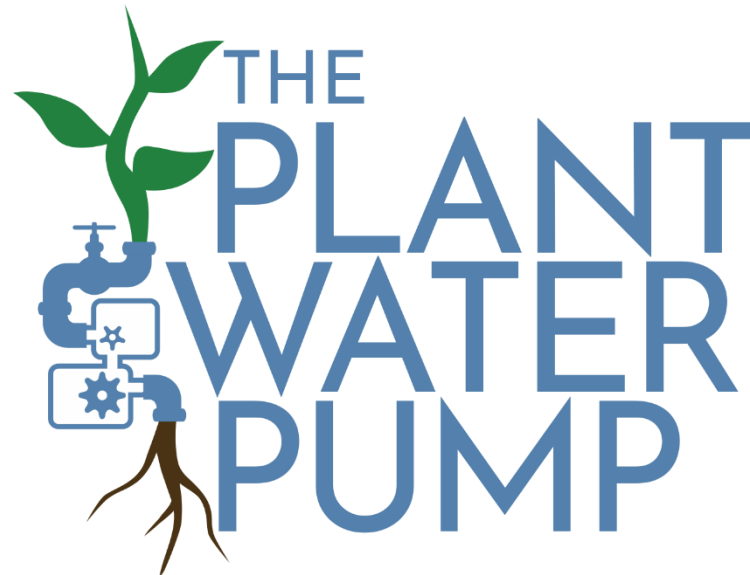
Suberin also does,
but in a much lesser extent !

Suberin in exodermis
keeps k_r higher than
with **suberin in endodermis**

ROLES OF SUBERIN ?

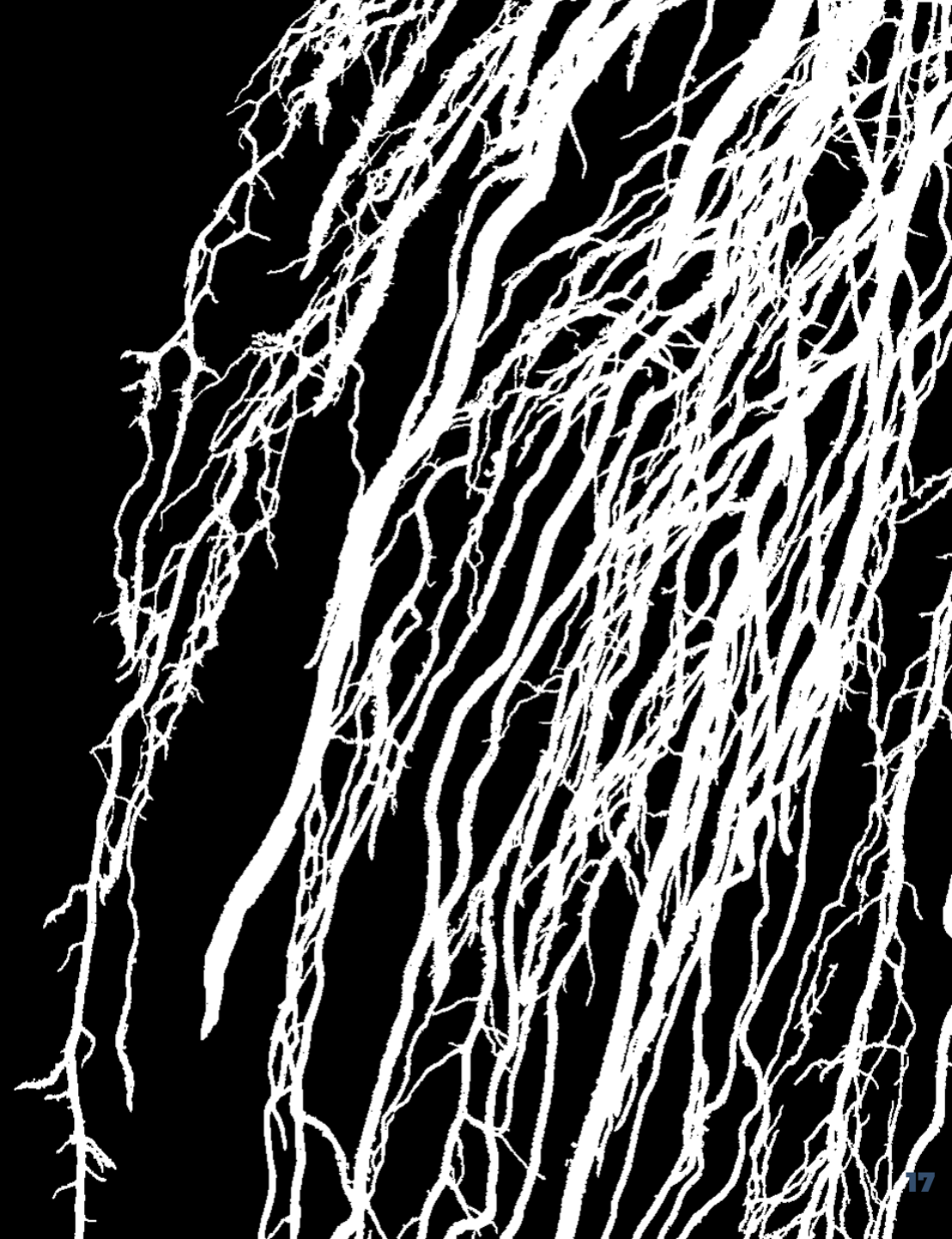


**Théo
Degand**
UCLouvain

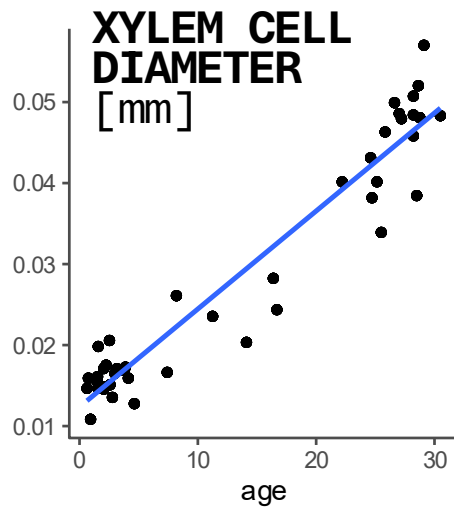
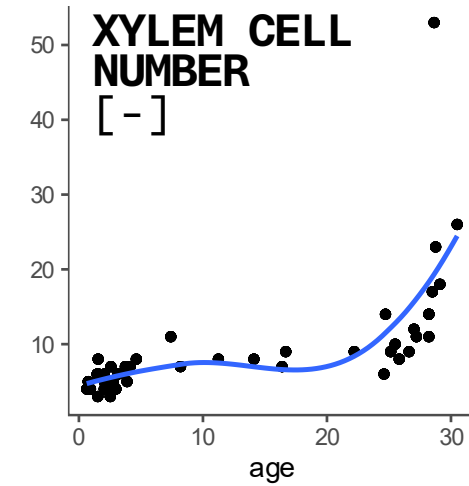


TOMORROW
12:45
GORILLA 5

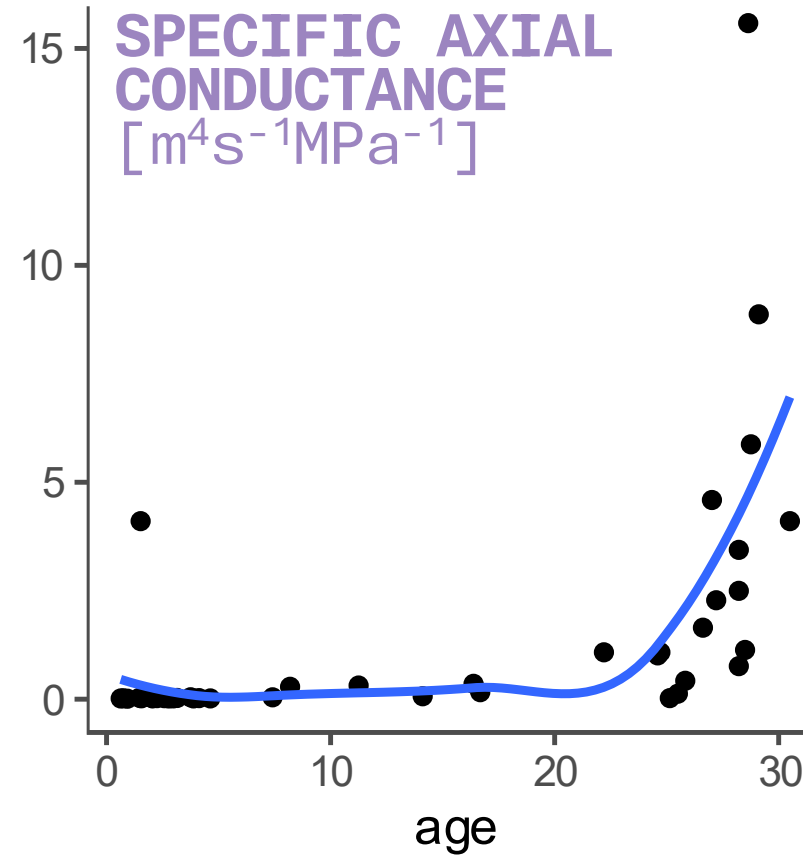
RESULT 2:
IMPACT OF
**SECONDARY
GROWTH**
ON **HYDRAULIC
PROPERTIES**



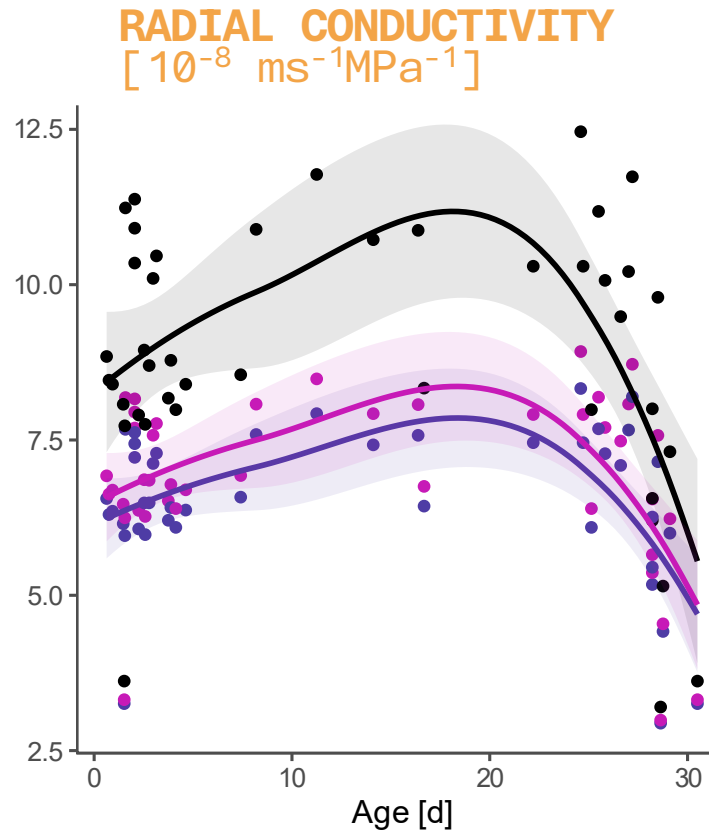
AXIAL CONDUCTANCE INCREASES WITH **SECONDARY GROWTH**



**HAGEN-
POISEUILLE**



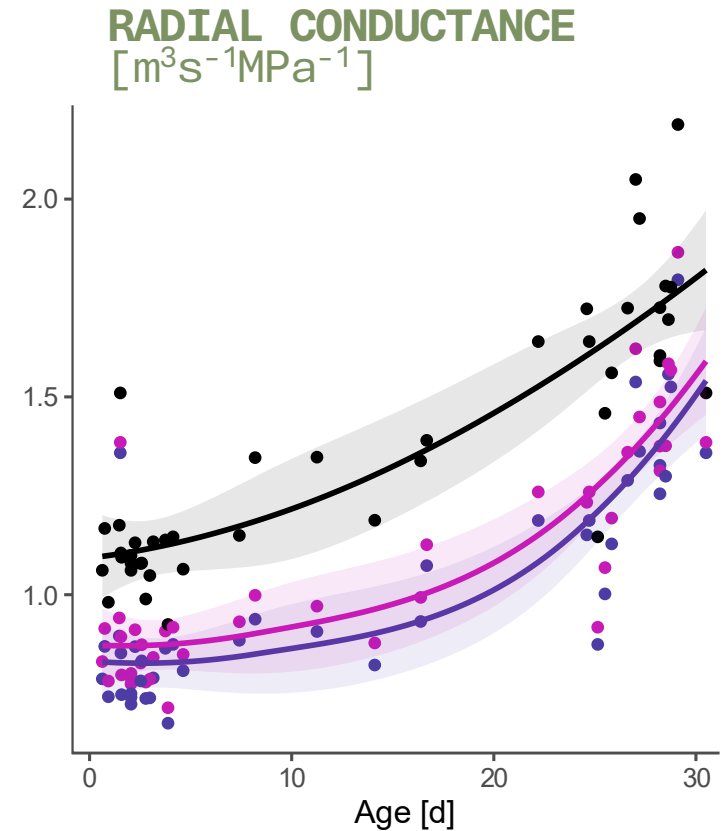
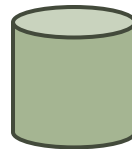
RADIAL CONDUCTIVITY DECREASES WITH SECONDARY GROWTH...



En . CS
En . CS+Ex . LC
En . CS+Ex . Sub



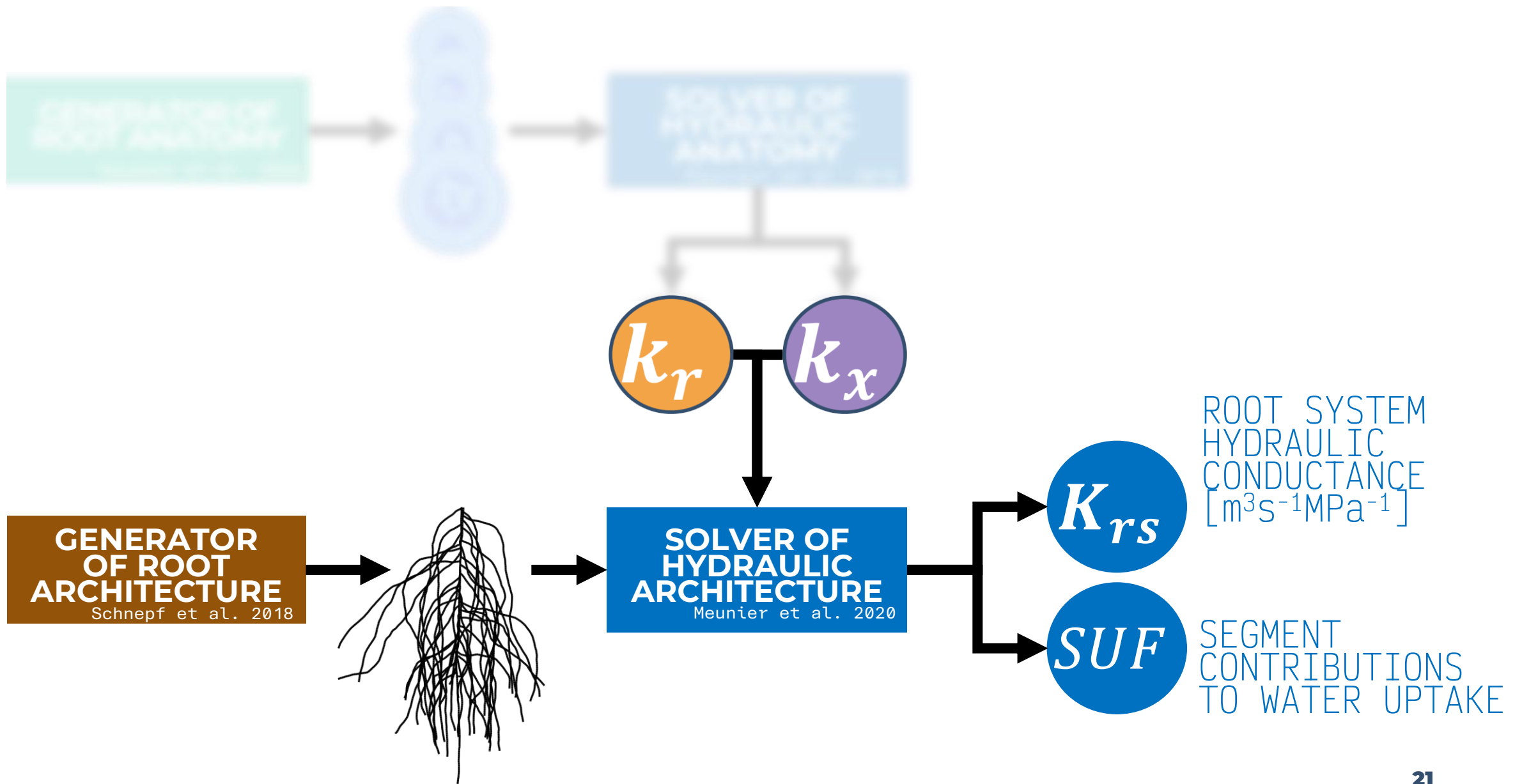
×
segment
surface



... AND **RADIAL CONDUCTANCE** INCREASES

APPLICATION:
APPLY
**HYDRAULIC
PROPERTIES** TO
TOMATO
**ROOT SYSTEM
HYDRAULIC
ARCHITECTURE**

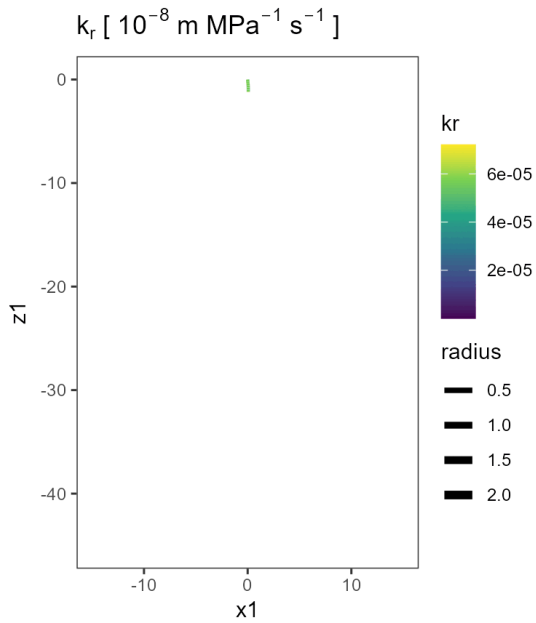




Time : 1.00 [d]

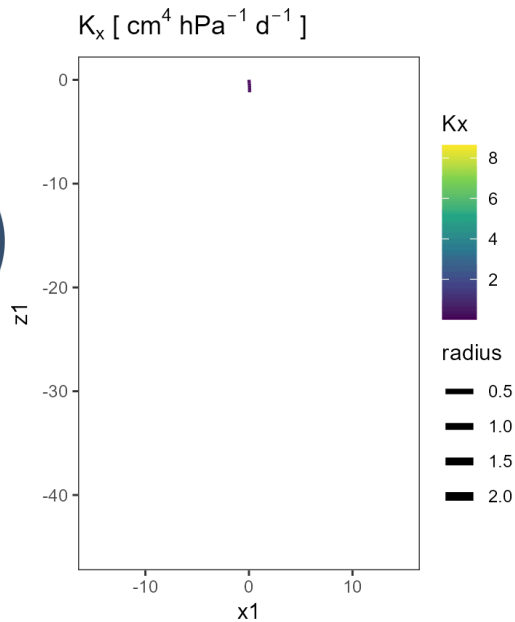
k_r

RADIAL HYDRAULIC
CONDUCTIVITY
[$\text{ms}^{-1}\text{MPa}^{-1}$]

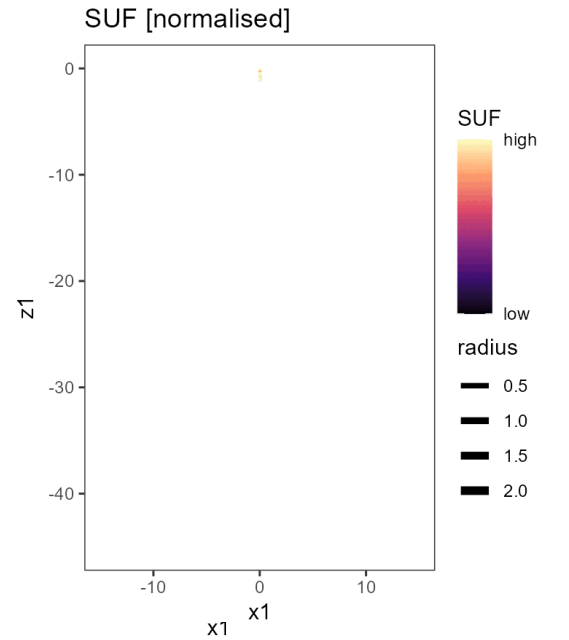


k_x

SPECIFIC
AXIAL HYDRAULIC
CONDUCTANCE
[$\text{m}^4\text{s}^{-1}\text{MPa}^{-1}$]

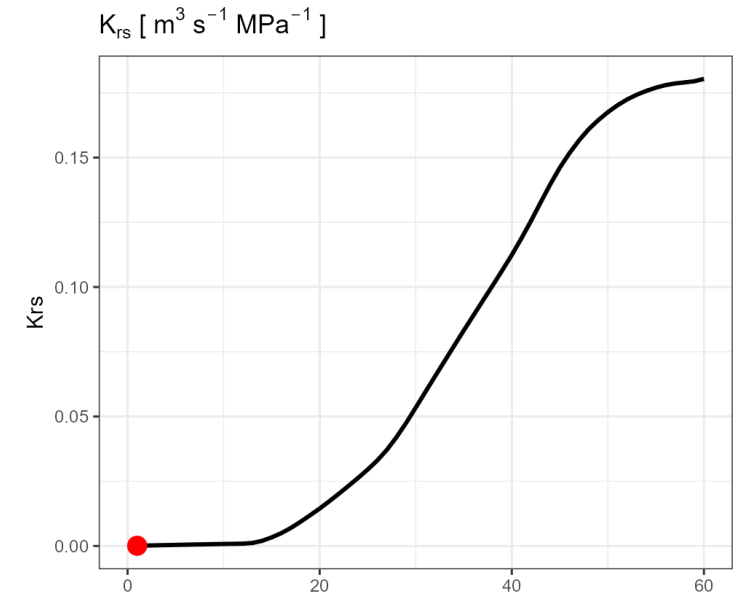


SEGMENT
CONTRIBUTIONS
TO WATER UPTAKE
[-]

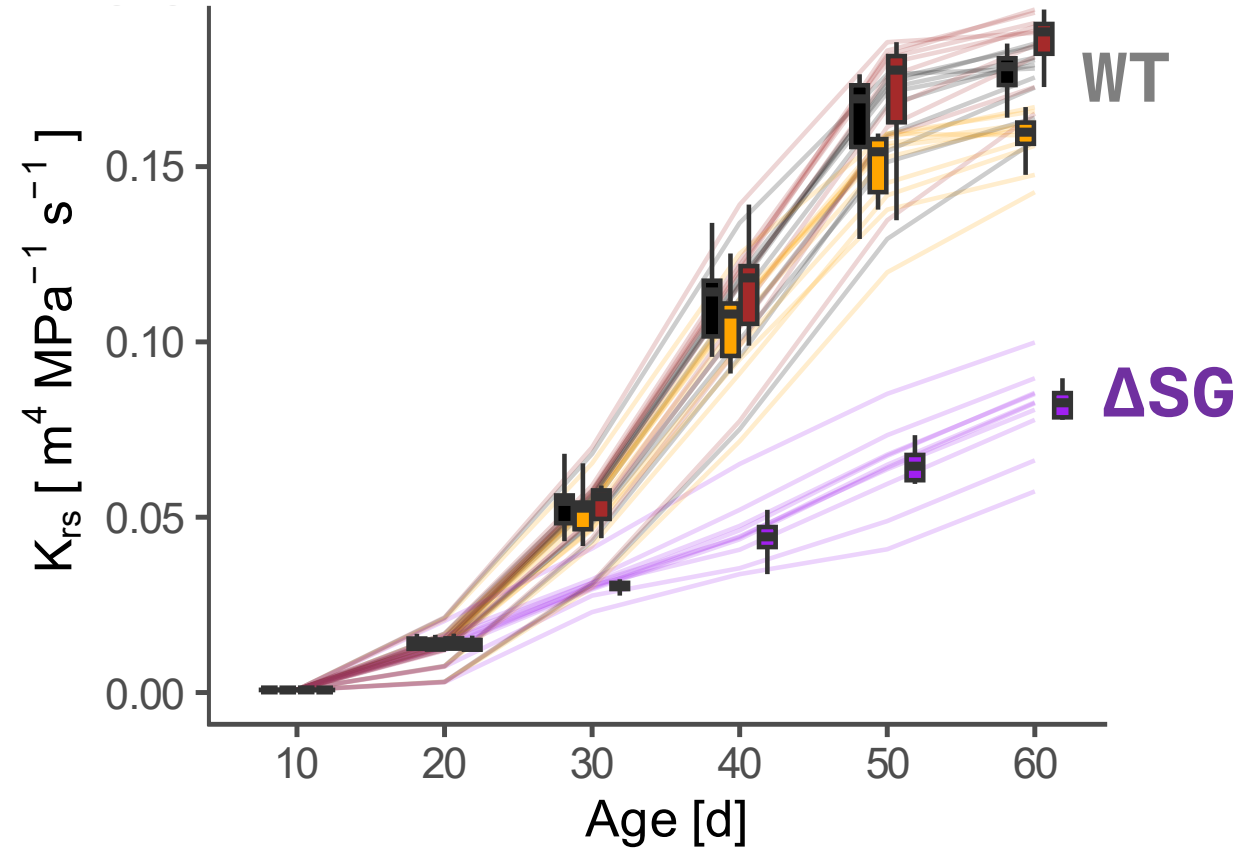


SOLVER OF
HYDRAULIC
ARCHITECTURE
Meunier et al. 2020

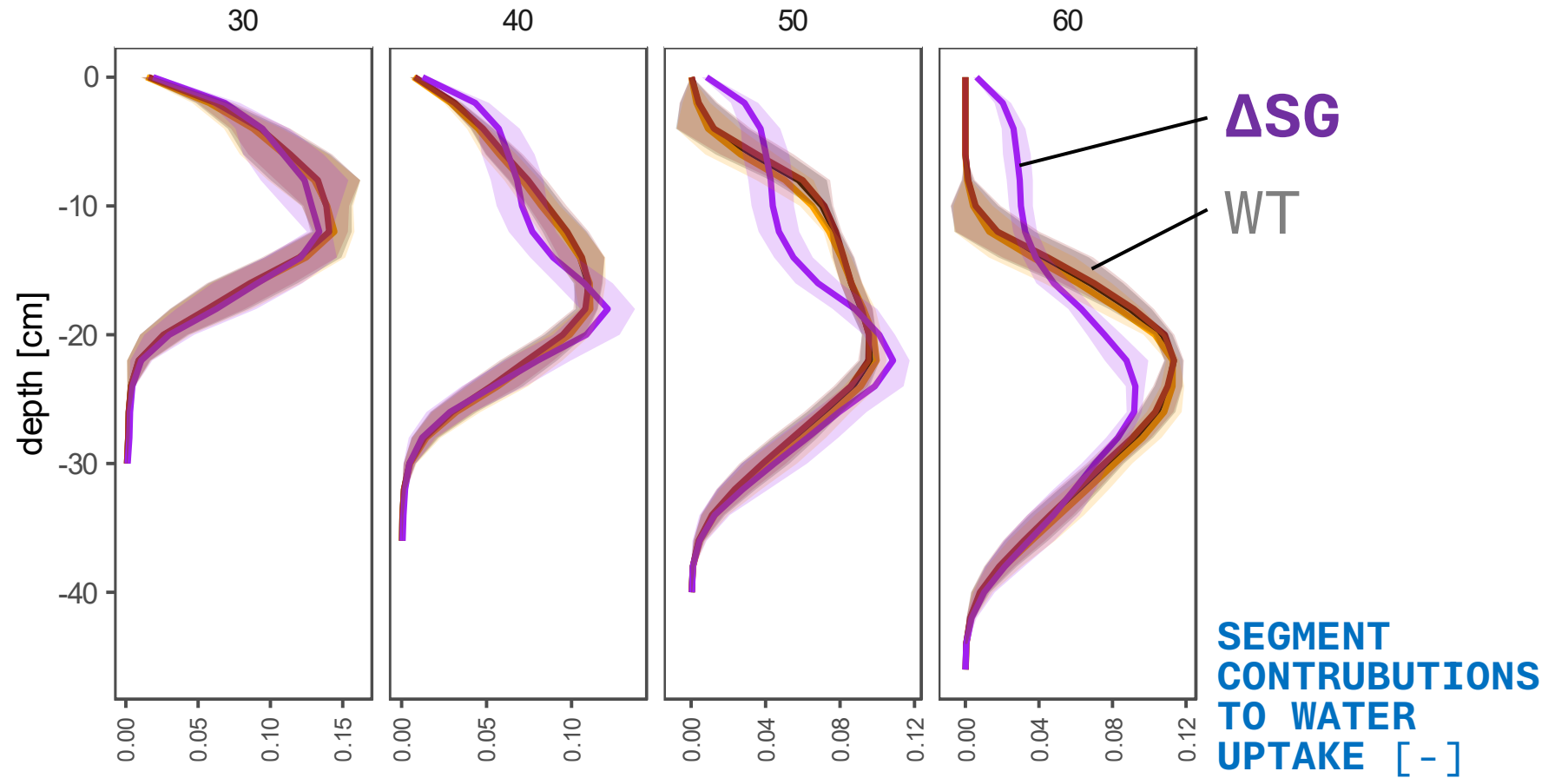
ROOT SYSTEM
HYDRAULIC
CONDUCTANCE
[$\text{m}^3\text{s}^{-1}\text{MPa}^{-1}$]



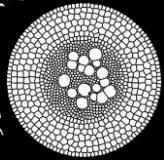
HIGHLIGHT 1:
SECONDARY GROWTH
ALLOWS FOR HIGHER
ROOT SYSTEM CONDUCTANCE



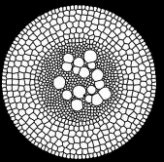
HIGHLIGHT 2:
SECONDARY GROWTH
SHAPES DIFFERENT
WATER UPTAKE PROFILE



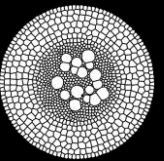
KEY MESSAGES



WE MODELED ROOT **HYDRAULICS PROPERTIES** IN FUNCTION OF **ROOT ANATOMY** AND **HYDROPHOBIC BARRIERS**



LIGNIN CAP IN EXODERMIS REDUCES k_r . **SUBERIN** ALSO DOES BUT IN A LESSER EXTEND.



SECONDARY GROWTH AFFECTS k_r AND SHAPES **MACRO-HYDRAULIC PROPERTIES**



THE TROOT TEAM



Rémy Schoppach



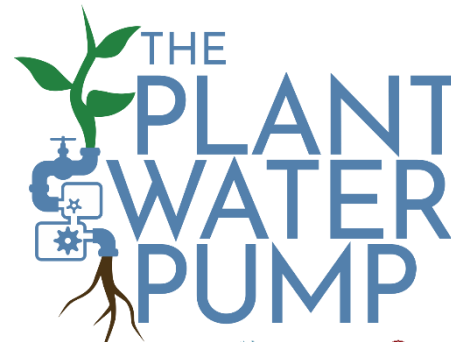
Adrien Heymans



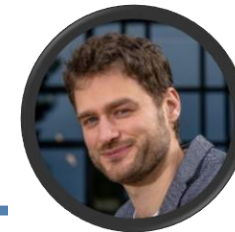
Guillaume Lobet



Valentin Couvreur



THE PLANT WATER PUMP



Valentin Couvreur



Lei Ding



Daniel Persson



Noémie Thiébaud



Monica Rothwell



Théo Degand

TOMORROW
12:45
GORILLA 5



Marco D'Agostino
marco.dagostino@uclouvain.be
@marcodago.bsky.social



PROTOCOLS

An Updated Protocol for High Throughput Plant Tissue Sectioning

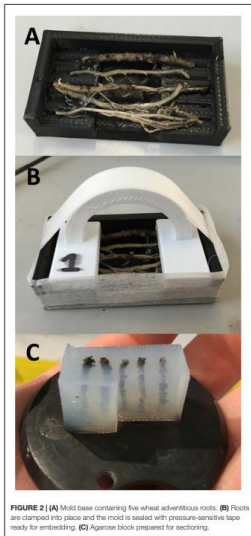
Jonathan A. Atkinson^{1,2*} and Darren M. Wells¹

¹ The Centre for Plant Integrative Biology, School of Biosciences, University of Nottingham, Nottingham, United Kingdom,

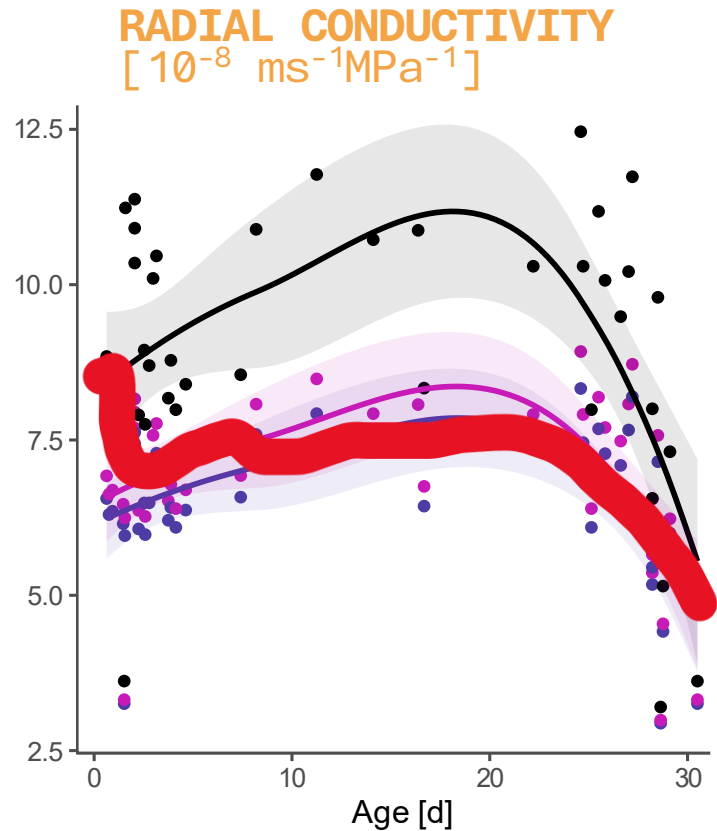
² BBSRC/Nottingham Wheat Research Centre, University of Nottingham, Nottingham, United Kingdom

Direct fluorescence imaging of lignocellulosic and suberized cell walls in roots and stems

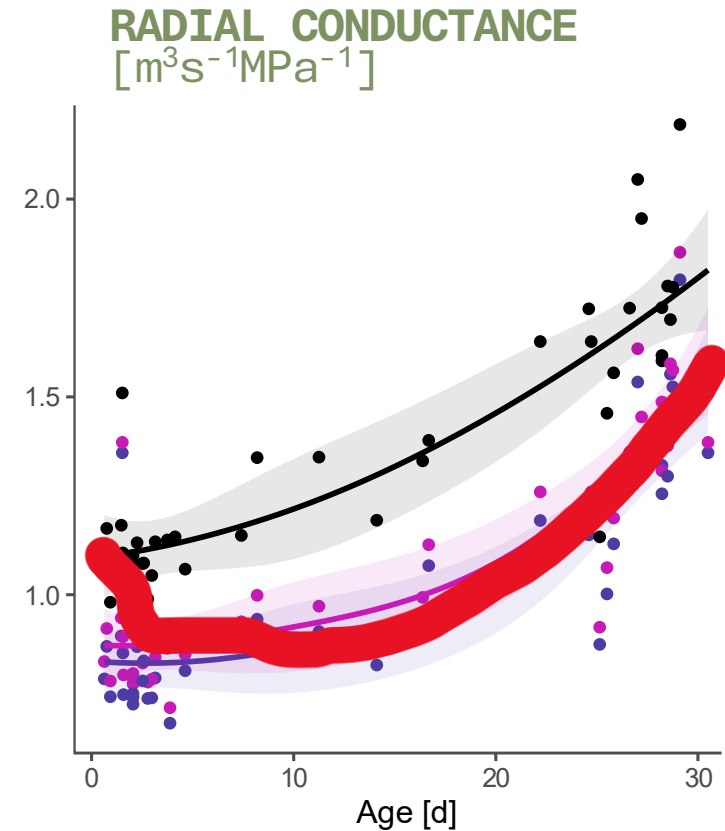
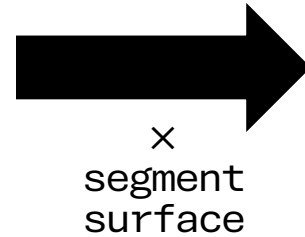
Peter Kitin^{1,2,*}, Satoshi Nakaba^{2,3}, Christopher G. Hunt⁴, Sierin Lim⁵ and Ryo Funada^{2,3}



RADIAL CONDUCTIVITY DECREASES WITH SECONDARY GROWTH...



En . CS
En . CS+Ex . LC
En . CS+Ex . Sub



... AND **RADIAL CONDUCTANCE** INCREASES

