Impact of the combination of several lateral root growth and anatomies on root system water uptake

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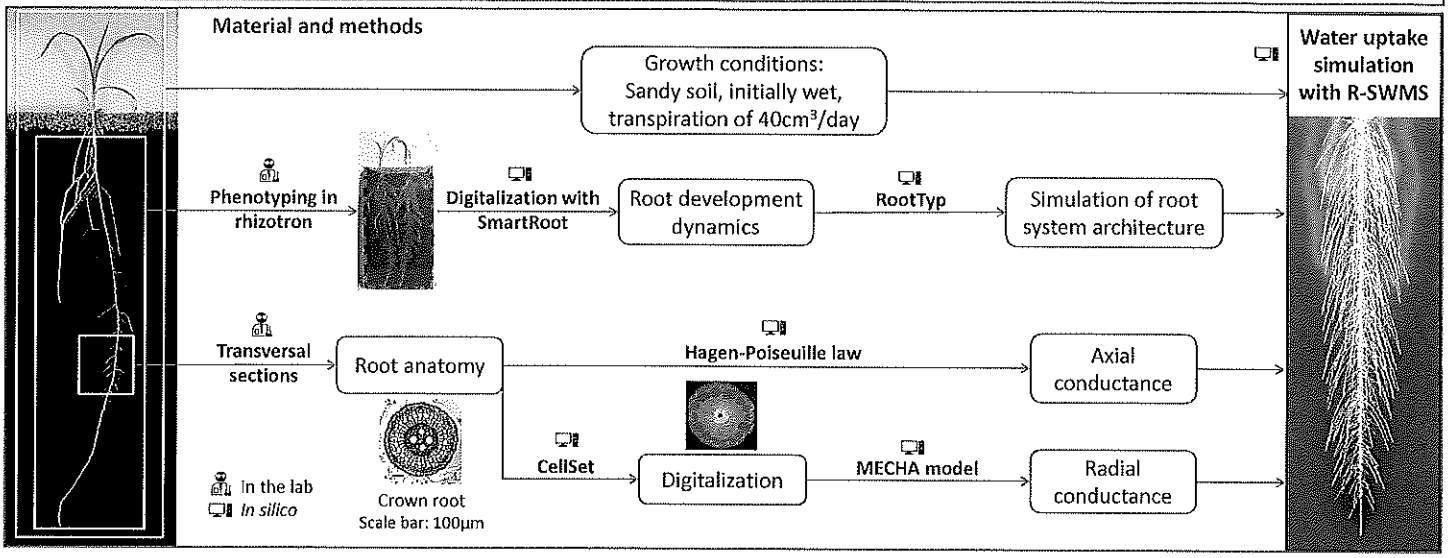
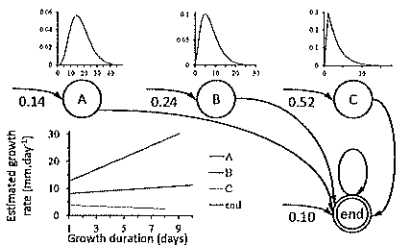
Context Diversity has been observed in the anatomy and growth patterns of lateral roots (LR) in cereals. This may impact water uptake and could therefore increase cereal performances under drought. This study focuses on pearl millet, a key crop for food security especially tolerant to drought.
Objectives The objective was to assess the impact of the existing diversity among lateral root growth and anatomies on water uptake using simulations.

Material and methods



Results

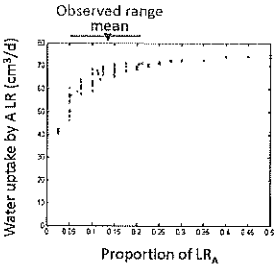
Using a semi-Markov switching linear model LR growth profiles cluster into three groups.



Growth profiles correspond to distinct LR anatomies with specific hydraulic properties ①

	LR A	LR B	LR C
Picture in autofluorescence (Scale bar: 20µm)			
Diameter	380 µm	250 µm	100 µm
Axial conductivity (xylem vessel dimension + Hagen-Poiseuille)	$2.5*10^{-16}$ µL/s.MPa.m²	$2.0*10^{-18}$ µL/s.MPa.m²	$6.0*10^{-20}$ µL/s.MPa.m²
Radial conductivity (digitized anatomy + MECHA)	$1.99*10^{-5}$ cm²/hPa.d	$1.38*10^{-6}$ cm²/hPa.d	$1,50*10^{-6}$ cm²/hPa.d

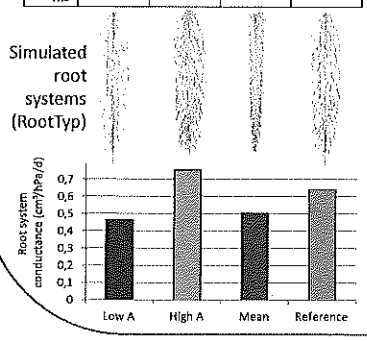
Simulations indicate that LR_A ③ take up most of water. Further simulations show that this contribution to water uptake reaches a plateau around the observed proportion of LR_A.

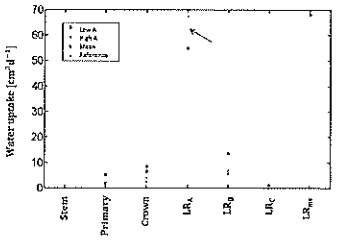


with $0 \leq \%A \leq 50\%$, $\%A \leq \%B$ & $0 < B$

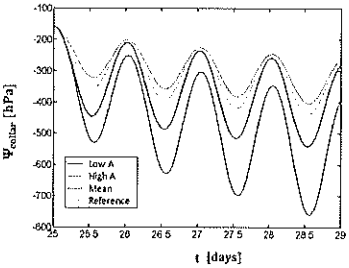
	Low A	High A	Mean	Ref.
LR_A	0.05	0.21	0	0.14
LR_B	0.18	0.30	0	0.24
LR_C	0.77	0.49	0	0.62
LR_{ms}	0	0	1	0

Simulations were done with **reference** architecture, with **extreme observed** proportions of LRs and with a synthetic "mean + sd" **homogeneous behavior** for all LRs. Transpiration is fixed (40cm³/d) while Ψ (water potential) at the collar depends on the ability of the root system to take up water. ②





LR_A take up most of water. Their contribution varies with their proportion in the root system.



Plants with only one type of LRs would experience drought earlier than those with three types, regardless of proportions

Conclusion
→ **Three types of LRs** in pearl millet based on **growth profiles & anatomy**
→ This diversity in LR properties would **delay drought sress**
→ **Largest LRs** contribute the most to water uptake and its usually observed proportion seems to be optimal for this.

Passot, S., Gnacko, F., Moukouanga, D., et al. (2016). Characterization of Pearl Millet Root Architecture and Anatomy Reveals Three Types of Lateral Roots. *Front. Plant Sci.* 7, 1–11.
Pagès, L., Vercambre, G., Drouet, JL., et al. (2004) Root Typ: a generic model to depict and analyse the root system architecture. *Plant and Soil* 258: 103.
Lobet, G., Pagès, L., and Draye, X. (2011). A novel image-analysis toolbox enabling quantitative analysis of root system architecture. *Plant Physiol.* 157, 29–39.
Couvreur V, Faget M, Lobet G, Javaux M, Chaumont F, Draye X. 2017. Novel multiscale insights into the composite nature of water transport in roots. bioRxiv, 147314.
Javaux, M., Schroder, T., Vanderborght, J., and Vereecken, H. (2008) Use of a three-dimensional detailed modelling approach for predicting root water uptake, *Vadose Zone J.* 7, 1079–1088.

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