Impact of three lateral root types identified in pearl millet on water uptake

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Context Diversity has been observed in the anatomy and growth patterns of lateral roots 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 provide an integrated description of pearl millet lateral root development at early stages and to assess the impact of the existing diversity among lateral roots on water uptake using simulations.

Material and methods

Phenotyping in rhizotron

Digitalization with SmartRoot

Root development dynamics

RootTyp

Simulation of root system architecture

Transversal sections

Root anatomy

Haagen-Poiseulle law

CellSet

Explicit cross section hydraulics

Radial conductance

Axial conductance

Growth conditions: Sandy soil, initially wet, transpiration of 40cm³/day

Water uptake simulation with R-SWMS

Results

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

Three distinct LR anatomies were found which correlate with groups based on growth profiles

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.

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

Conclusion

⇒ Three types of LRs identified in pearl millet based on growth profiles & anatomy
⇒ Existence of three distinct types would delay drought stress
⇒ Largest LRs contribute the most to water uptake and their contribution reaches a plateau around the usually observed proportions of LRs