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

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Water uptake is a challenge for crops growing in regions where sandy soils and low rainfalls are frequent. Plant species evolving in these regions, such as pearl millet which has been domesticated in Sahelian Africa, provide interesting models to identify and analyze mechanisms of tolerance to water limitations. The objective of this work was to understand how the root architectural traits of young pearl millet plants improve water uptake under challenging conditions with modeling approach. We followed the growth of pearl millet root systems on a daily basis during two weeks and observed a large variability among lateral root growth profiles. To further analyze this diversity, a statistical model was designed to classify these roots on the basis of their growth profiles. Three categories of lateral roots were identified in this way, which corresponded to distinct anatomies previously described on pearl millet. We used the MECHA model to predict hydraulic properties of the different root categories based on their anatomy and the RootTyp model to simulate typical root system architectures. These data were then used to simulate water uptake by the root system with the R-SWMS model. Comparison of the simulated conductance with measurements done in pressure chamber validated the relevance of this association of models for water flux simulations. We performed various simulations to assess (i) the value of combinations of different root categories within a root system, (ii) the relative contribution of each category to water uptake and (iii) the impact of their relative proportions on global water uptake, in the context of dry and sandy soils.