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Dynamic niche partitioning of water use in diverse ecosystems is affected by the presence of plant functional groups

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Efficient water uptake in ecosystems is strongly related to plants being able to adapt root water uptake to resource availability. In the last years, it has been increasingly acknowledged that root water uptake can vary quickly with time and also deviate substantially from root length densities. However, there is still little knowledge about which ecosystem properties affect deviations of the root water uptake profiles from the root length density profile. Here we investigated whether deviations of root water uptake from the rooting density profile were related to ecosystem structure in terms of species diversity and abundance of functional groups.

We investigated root water uptake profiles in 12 established grassland ecosystems in the ECOTRON facility in Montpellier. The macrocosms were extracted soil monoliths (2 m deep, surface area 2 m^2) from a grassland biodiversity experiment (Jena Experiment) and were established for 10 years at the time of excavation. We derived root water uptake profiles based on daily fluctuations of volumetric soil water content assessed in several depths. Ecosystem evapotranspiration was derived from the weight change. After the end of the experiment, root sampling was conducted to derive root biomass and root length density profiles in each macrocosm.

Root water uptake derived from variations in soil water content compared very well with the evapotranspiration derived from the lysimeter weight changes. Root length density profiles were very similar in all 12 ecosystems. Root water uptake corresponded surprisingly well to root length density profiles in communities with low species diversity. In contrast, root water uptake deviated substantially from the root length density profiles in diverse grassland communities. Further investigations suggest that this difference was caused by a better development of tall herbs (as compared to legumes and grasses) in the diverse ecosystems.

Our results suggest that deviation of root water uptake from root length density is strongly related to the structure of the ecosystem, and in particular to the presence of species with strongly differentiated root systems.