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Where do maize roots take up water? The importance of different root type

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The ability of plants to take up water from the soil depends on both the root architecture and the distribution and evolution of the hydraulic conductivities among root types and along root length. Maize (Zea mays L.) is one of the most important food crops worldwide. Despite its importance, there is limited information on the function of different root types in extracting water from soils. The objective of this study was to investigate the location of root water uptake in maize growing in soil.

The maize root stock has a unique architecture that comprise of several root types forming at different developmental stage. We measured the location of water uptake in young and mature maize roots system. We used neutron radiography to image the spatial distribution of maize roots in soil and trace the transport of deuterated water (D2O) in soil and roots. The transport of D2O was simulated using a diffusion–convection numerical model. By fitting the observed D2O transport, we quantified the diffusion coefficient and the water uptake of the different root segments. The root architecture of a two-week-old maize consisted of a primary root, 4-5 seminal roots and many lateral roots. Laterals emerged from the proximal 15 cm of the primary and seminal roots. Water uptake of lateral roots was much higher than the uptake of seminal roots, which were unable to take up water from the distal unbranched segments. Three weeks later, this profile of root water uptake completely changed. The root architecture of five-week-old maize consisted of seminal roots with long laterals and crown (nodal) roots with shorter and fewer laterals. Water was mainly taken up by crown roots and their laterals, while laterals of seminal roots, which were the main location of water uptake in younger plants, had a minor contribution to root water uptake. In contrast to seminal roots, crown roots were able to take up water also from their most distal segments. The greater uptake of crown roots compared to seminals is explained by their higher axial conductivity in the proximal parts and by the fact that they are connected to the shoot above the seminals, which favors the propagation of the xylem tension along the crown roots. The deeper water uptake of crown roots is explained by their shorter and fewer laterals, which decreases the dissipation of water potential along the roots.

We concluded that for a two-week-old maize the function of lateral roots is to absorb water from the soil, while the function of the primary and seminal roots is to axially transport water to the shoot. On the other hand, crown (nodal) roots were the main location of water uptake in mature maize.

Overall, we demonstrated the importance of acknowledging the specific hydraulic properties of different root types. We believe that our results would significantly advance our current view on roots function and we hope that this would facilitate new avenues to identify optimal root traits.