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Measurements of water uptake of maize roots: insights for breeders

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The ability of crops to capture water from the soil depends on the root architecture and anatomical root traits that determine their radial and axial hydraulic conductance. These properties are not constant but vary along roots and among different root types and their measurement as well as their effect on the location of water uptake remain an open scientific challenge. The objectives of this study were to measure water uptake by maize roots in soils and estimate differences between seminal, nodal and lateral roots. We traced the transport of deuterated water (D_2O) in the roots of a five-weeks-old maize in sandy soil using neutron radiography. The transport of D_2O was simulated using a diffusion-convection numerical model, which gave the radial permeability and the water uptake of the different root segments. The measurements of the fluxes were complemented with measurements of the axial hydraulic conductivities of seminal and crown roots at different positions. The root architecture of a five-weeks-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 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 conclude that laterals of seminal were the main location of water uptake in young maize whereas crown roots were the main location of water uptake in mature maize. Thus, breeding for lateral roots with high radial conductivity and seminal roots with large xylem vessels diameter would be beneficial in agroecosystems where water is available. In contrast, in arid and semi-arid areas seminal roots with a smaller xylem vessel diameter combined with crown (nodal) roots with steep growth angle would not only conserve water early in the season but also at the same time allow the uptake of water stored in the subsoil.

Keywords: Root water uptake, Zea mays, crown roots, seminal roots, neutron radiography, diffusion-convection model