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Review and Prospect of hydraulic behavior research of rhizosphere, xylem and leaves using neutron imaging

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Neutron radiography which images interactions within the nucleus of atoms, rather than between electrons like X-ray (1), can identify the strongly interacting hydrogen in water molecules, and can be used to determine hydraulic behavior in soils and plants. The first of a series of neutron imaging (NI) is able to determine the water content and morphology of roots planted in pots embedded in the field. The results of a series of neutron imaging were used to diagnose root diseases in situ (2).

Therefore, neutron imaging is the most appropriate method for studying the epidemiology of root-rot and rust because it can detect significant accumulations of inorganic elements of iron, aluminum, silicon, and magnesium ions and water of root in the soil, all of which interact with the fungi, mycorrhiza, and yeast inocula in the rhizosphere(3). The levels of water, phenolics, and inorganic elements in the roots are all indicators of root health.

The uptake of water and inorganic elements by roots is a crucial process for plant health. Dielectric cell pressure probes, magnetic resonance, and heat tracing can be used to map the fluid dynamics in the xylem sap and phloem, but they are destructive methods. By contrast, neutron dynamic imaging produces a 3D picture (4) of hydraulic movement in the vessels and sieve tubes, depending on solution ion concentration, pH, root pressure, osmotic pressure, capillarity, and nonpolar solvents during active metabolism and photosynthesis. Hydraulic movement from the root epidermis to the endodermis, apoplast, symplast, and transmembrane regions can be analyzed in vivo (5). Neutron imaging with the contrast agent, D2O, can be used to visualize in situ photomorphogenesis in the plant roots based on the sensitivity to different light wavelengths. These phenomena are largely uncharacterized at present. The application of neutron imaging shows us great promise for addressing many of the challenging questions related to plant hydraulics in the rhizosphere. In this paper, the related research will be reviewed and be looked in to the future of neutron imaging tools for an expanding agricultre and food field.

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