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Application of MRI T1 mapping on root soil interactions

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Relaxometric imaging has already been known in MRI of natural porous media and plants for some decades. Mostly T2 maps are determined due to the relatively short measurement time. However, T2 is often accelerated by diffusion processes in internal gradients caused by the high magnetic field strengths typically encountered in MRI. Therefore, the information can not be unambiguously assigned to pore structure changes. In this work we will show that T1 mapping is more suitable and allows the characterization of water mobility in porous media and the monitoring of flow patterns using paramagnetic tracers. We can show that errors due to cross talk artefacts in multi-slice sequences with short repetition times and inhomogeneous spin density and T2 decay can be overcome by determining a complete T1 map. In doing so we monitor a series of inversion recovery filtered images with different inversion times which are normalized on a reference image with identical settings but no inversion recovery filter.
The validity of the approach is proven by recovering the total amount of a paramagnetic tracer injected in a natural porous medium. In the next step we apply the method to two systems that are of great interest in soil-plant research: First, patterns of water flow and root uptake pathways are visualized by monitoring the motion of a paramagnetic tracer. Using this T1 mapping approach a wide range of tracer concentration manifesting in a broad relaxation time range is accessible. By analyzing the observed accumulation patterns, it is possible to conclude on roots with high or less uptake activity within the same root system.
The second example concerns the detection of zones in the immediate vicinity of the root surface with reduced T1 relaxation times compared to bulk soil. In this zone, called the rhizosphere, the pore system can be altered by plant exudates such as mucilage or root hair growth, which reduce the effective pore size and explain the shorter relaxation time. In summary, the mapping of T1 is a very valuable tool for the study of important root-soil processes such as tracer movement and characterization of water mobility in the rhizosphere.

References

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