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Reconstructing root system architectures from non-invasive imaging techniques for the use in functional structural root models

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The combination of functional-structural root-system models with root architectures derived from non-invasive imaging is a promising approach for gaining a better understanding of root-soil interaction processes. However, root architectures can often not be fully recovered using imaging, which subsequently affects the assessment of function via the functional-structural root models. In this study, we explored theoretical and actual possibilities of root system reconstruction from MRI and X-ray CT images. Experiments with water-filled capillaries showed the same minimum detectable diameter for both MRI and X-ray CT for the used parameter setup. Experiments with soil-grown lupine roots, however, showed significantly lower root system recovery fractions for MRI than for X-ray CT, from which most roots thicker than 0.2 mm could be recovered. MRI allowed root signal detection below voxel resolution; however, the connection of this signal to a continuous root structure proved difficult for large, crowded root systems. Furthermore, soil moisture levels >30% hampered root system recovery from MRI scans in experiments with pure sand. To overcome the problem of low root system recovery fractions, we developed a new method that uses incomplete root systems as a scaffold onto which missing roots are simulated using information from WinRhizo measurements. Comparisons of root length within subsamples of semi-virtual root systems and root systems derived from X-ray CT scans showed good agreement. Evaluation of hydraulic root architecture measures of incomplete root system scaffolds and semi-virtual root systems proved the importance of using complete root system reconstructions to simulate root water uptake. Semi-virtual root reconstruction thus appears to be a promising technique to complete root systems for subsequent use in functional-structural root models.