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Assessing differences in soil structure and biopore networks, generated by three precrops, using 3D image analysis

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Crop sequences are commonly suggested as an alternative to improve subsoil structure, as they are able to generate extensive networks of biopores. Nevertheless, assessing soil structure remains a great challenge, as it can be characterized in different ways, many of them relying on subjective criteria. Our main goal was to objectively characterize soil structure by means of 3D image analysis, assuming that different root systems will significantly re-shape pore networks of natural soil pore systems.
We analyzed the influence of three crops with either shallower roots (Festuca arundinacea, fescue) or taproots (Cichorium intybus, chicory and Medicago sativa, alfalfa). The crops were cultivated on a Haplic Luvisol near Bonn (Germany) for three years. Undisturbed PVC soil cores of 96 cm3, were taken at 45, 60 and 75 cm depth. After equilibration at -15 kPa matric tension, the cores were scanned with a X-ray microtomograph achieving 51 μm voxel resolution. By means of image processing (segmentation, volume threshold and morphological filtering) we isolated the biopores from the rest of the pore network, defining two domains: pores in the rhizosphere (up to 5 mm lateral distance to a biopore wall, RP) and the complementary matrix-pores (MP). We analyzed the connectivity of the matrix pores to the larger biopores by quantifying the distances of random voxels to the nearest biopore. Furthermore, we obtained geometrical features like pore size distributions as well as morphological parameters (Euler number and integral of mean curvature) on both domains and on the complete cores.
Differences in pore size distribution were observed between depths and crops, both taproot crops (alfalfa and chicory) presenting higher macroporosity in depth. Furthermore, both taproot crops showed great impact on the pore morphology parameters which can be used as proxy for connectivity between soil layers. Also the distance analysis of random voxels revealed great differences between different depths and crops being significantly shorter for the taproot crops at 75 cm. This indicates that the microscale connectivity and hence the potential accessibility of the matrix pore domain als well as the gas transport between the soil matrix and the free atmosphere through such connected pores is improved. No relevant differences were found between RP and MP when compared for the same crop/depth. This confirms further studies showing the high impact of the soil structure that was present before the experimental setup.