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Visualisation and quantification of wheat root system architecture and soil moisture distribution in an aggregated soil using neutron computed tomography

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Sustainably intensifying global crop production in a world of diminishing natural resources is paramount for the attainment of zero hunger worldwide (a United Nations sustainable development goal). Key to this sustainable intensification is a deep understanding of the dynamics and complexities of plant-soil interactions for optimisation of plant productivity. Neutron computed radiography and tomography are powerful, non-invasive tools that enable the characterisation of plant-soil systems in situ. They also enable the visualisation and quantification of water distribution and movement within plant-soils systems. In this novel study, we use high resolution neutron computed tomography to investigate root system architectural differences in two different genotypes (Wild type vs TaEPF1-OE1-water use efficient mutant line) of bread wheat (Triticum aestivum). We further investigated how wheat roots interact with the heterogeneously distributed soil moisture. For this investigation, plants were grown in an aggregated sandy loamy soil with moderate amounts of organic matter (4%) for 13 days prior to imaging. We were able to produce a detailed three dimensional visualisation of the root architectural distribution of the two different genotypes imaged. These did not show significant differences between the two genotypes under investigation. We were also able to visualise relative soil moisture distribution and made inferences to how the roots of the wheat plants under investigation interact with the heterogeneously distributed soil moisture. Our results showed increased lateral root growth in regions with finer soil aggregates that had an estimated lower moisture content as compared to larger soil aggregates that retained higher amounts of moisture. This study demonstrates that detailed investigations into plant-soil interactions using neutron imaging techniques can be done successfully even in aggregated soils with considerable amounts of organic matter. This is a departure from the majority of neutron imaging experiments that predominantly use disaggregated sand soils devoid of organic matter as a growth medium.