EGU2020-5061
https://doi.org/10.5194/egusphere-egu2020-5061
EGU General Assembly 2020
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Spatio-temporal dynamics of root system architecture of maize in a field trial during a growing season

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A better understanding of how roots explore soil is crucial for plant breeding, yield increase and sustainable agriculture. This requires detailed knowledge about the temporal dynamics of root system architecture under field conditions, which is hard to achieve as sampling of roots with unconstrained growth (no root windows) is very laborious.

Here we present the results of a major undertaking to sample maize roots in a field experiments at four growth stages in various depths (0-20, 20-40, 40-60 cm) with two different methods: a) destructive sampling with a root corer and root washing vs. b) undisturbed sampling combined with root detection in X-ray CT images. The first method results in root length data with a higher number of technical replicates per depth and plot, whereas the second provides more details of small-scale rooting patterns and plant-soil interactions in intact soil for a smaller number of samples.

The aim of the study was to explore differences in spatio-temporal root growth patterns between two different maize genotypes (wild type vs. root hairless mutant) growing in two different homogenized substrates (sand vs. loam). For disturbed sampling we found that for both genotypes root growth was more vigorous in sand during the entire growing season. This was remarkable since shoot biomass was larger on the loam plot. As drought developed during the growing season, root length density profiles reversed in loam, but not on sandy substrate. For intact cores we find the same trends so that they can now be analyzed towards inter-root distances at shorter scales.

In loam the absence of root hairs and the associated reduction of available surface for water and nutrient uptake resulted in a 50% reduction in shoot biomass, whereas root length profiles did not differ in the root corer data. In sand differences in shoot biomass between genotypes were comparable, but here root length densities were lower for the root hairless mutant in the root corer data. Unexpectedly there was no compensation of lacking root hairs by enhanced root growth. The root length data in intact samples showed higher variation due to smaller sampled volumes which disguised possible trends between genotypes.

In summary, the different hydraulic properties of the substrates had a strong effect on root growth and root distribution with depth, whereas the genotype governed shoot biomass supposedly through differences in nutrient and/or water uptake efficiency mediated by the

presence or absence of root hairs. As the next steps, these observations will be underpinned by transpiration and soil moisture monitoring data as well as plant nutrient uptake data.