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How far roots and exudates can transform the soil structure and porosity?

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Aims
The impact of plant-roots on soil physical porosity and structure is still to be deciphered. Recent results revealed root-induced increases in soil pore volume whose magnitude could not be attributed to root-drilling effect, thus suggesting an indirect effect via microbial activity enhanced by root exudates (Milleret et al., 2009, Kholer-Milleret et al., 2013). This is discussed in the present study by quantifying the soil hydro-structural changes induced by root exudates and microorganisms in the absence of roots.

Methods
The experiment was performed on series of structured repacked samples from two soils previously experimented with plants in mesocosms (Anthrosol and Luvisol). The samples received a daily input of artificial root exudates for three months. The soil structural changes were then assessed using shrinkage analysis and aggregate stability test. Microbial activity was measured with CO_2 emanation.

Results
In agreement with previous findings, root exudates increased microbial activity and aggregate stability. Oppositely, the observed structural changes were contradictory both in magnitude and pattern with those observed in the presence of plant roots. The soil bulk porosity was almost not changed while the small-diameter structural porosity was decreased in the presence of root exudates. Moreover, the hydro-structural stability of the soil decreased while the aggregate stability increased.

Conclusions
Though the structural changes observed in the presence of roots cannot be attributed to direct root drilling effect, they are not observed when only root exudates are delivered to the soil. Our results suggest that the soil structure is engineered by a complex soil-plant-microbe interaction combining root mechanical effect and micro-aggregate stabilisation effect. Cumulative structural pore volume increase could result from aggregates rearrangements induced by root growth, either by drilling or lever effect, further stabilized by microorganism's activity and exudates.

Kohler-Milleret, R., R.-C.L. Bayon, C. Chenu, J.-M. Gobat, and P. Boivin. 2013. Impact of two root systems, earthworms and mycorrhizae on the physical properties of an unstable silt loam Luvisol and plant production. Plant Soil: 1–15.
Milleret, R., C. Le Bayon, F. Lamy, J.M. Gobat, and P. Boivin. 2009. Impact of root, mycorrhiza and earthworm on soil physical properties as assessed by shrinkage analysis. Journal of Hydrology 373: 499–507.