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ABSTRACT

Numerous factors can explain the variability of root architecture, including genetics, environment and developmental instability (Forde, 2009), but the mechanical interaction between growing roots and the soil substrate has often been under-estimated. In particular, for modeling the root architecture it is essential to characterize the forces experienced by a root during its growth. We hypothesize that the heterogeneous structure of soil at the particle scale can significantly influence root growth trajectories and its ramification system.

We used a numerical discrete-element (Radjai & Dubois, 2011) model to simulate the mechanical interactions between the soil and a growing root. The simulations allow characterizing the reorganization of grains under the action of root forces. By return, the forces experienced by the root during its growth can be estimated numerically at the root cap. Sensitivity analyses of this force signal to root stiffness and granular properties have been performed. For all values of root stiffness, we find the same broad distribution of forces normalized by the mean force, indicating that the force experienced by the root reflects the distribution of contact forces inside the soil. Interestingly, we find that the mean force increases with root stiffness up to a threshold. For all values of packing fraction, we get a general scaling by normalizing the mean force by soil hardness obtained for an infinitely rigid root. In other words, for root growth the soil characteristics are fully captured by their effect on the hardness, which appears to be the only control parameter of root growth.

REFERENCES

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