INTERNSHIP PROPOSAL

(One page maximum)

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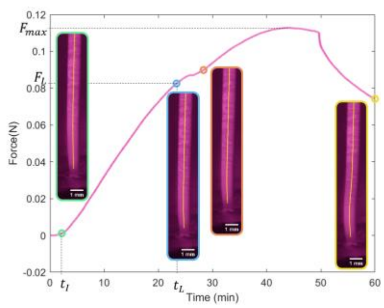
Thesis possibility after internship: YES
Funding: NO (EDPIF concours)   If YES, which type of funding:

Title: Biomechanical responses of plant root growth to mechanical stresses

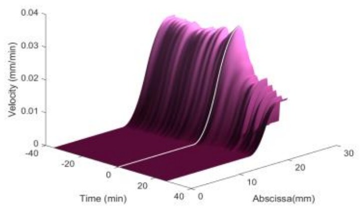
The interaction between plant roots and soils is a wide and interdisciplinary issue involving many communities from biophysics, agronomy, soil science to civil engineering and geophysics. The presence of zones of high mechanical resistance in the soil is one of the most common physical limitations to soil exploration by roots, which has direct impacts on yield crops. The root growth and trajectory highly depend on the presence of strong soil layers or obstacles at the root scale. The root apex must exert a growth pressure to overcome the resistance to deformation of the surrounding soil or reorient its growth to skirt around obstacles.

In the PMMH laboratory, we developped model experimental systems to study how the root changes its growth when encountering a single or a collection of obstacles mimicking the mechanical heterogeneities in a soil. In particular we investigated the growth response of a root (i) pushing against a single obstacle such as a force sensor or (ii) growing inside a 3D-printed array of stiff obstacles. For instance, by coupling force (Fig. i1) and kinematic measurements under infra-red lighting (Fig. i2), we probed the force-growth relationship of a primary root contacting a stiff resisting obstacle, that mimics the strongest soil impedance variation encountered by a growing root.

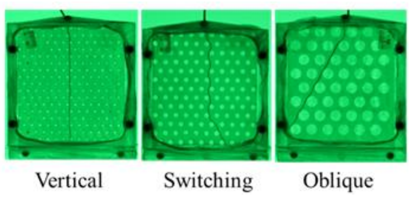
Different subjects are possible around the interaction of roots with mechanical obstacles.
One possible topic is 1) to investigate the response of the root to prescribed indentation steps to study its time-dependant mechanical properties and 2) to decouple the mechanical and biological responses by using a feedback loop on the applied force on the root. Another topic is 3) to use microfluidic systems to build arrays of granular substrates of soft hydrogel to vary the stiffness of obstacles encountered by roots and investigating the biomechanical parameters explaining the root trajectories in mechanically heterogeneous soils.



(i1) Evolution of the axial force exerted by a growing root pushing against a force sensor (acting as an obstacle) and visualization under infra-red lighting of the root texture.



(i2) Local growth velocity along the root length (obtained from a PIV-derived technique of the root texture) at different times, before and after contact (indicated by the white line).



(ii) Maize root growing in arrays of 3D-printed cylinders embedded inside an agarose gel. The root's diameter is around 1 mm.

Condensed Matter Physics: YES   Soft Matter and Biological Physics: YES
Quantum Physics: NO   Theoretical Physics: NO