The mechanical response of plant leafs to impact loading

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Pathogens are responsible for the loss of about 15% of the total agricultural production worldwide. Plant pathologists have long ago established the causal link between heavy rainfalls and disease outbreaks. Nevertheless, the mechanism through which pathogens are ejected from one plant to another has only been revealed very recently [1]: raindrop impacts trigger the break-up and subsequent dispersal of contaminated liquid puddles at the leaf surface. The efficiency of such scenario strongly depends on leaf compliance. Indeed, leaves may experience violent deformations in response to raindrop impacts. The corresponding local accelerations can then induce liquid break-up. The contaminated droplets seem to partially inherit from the local leaf velocity. The mechanical properties of a leaf change with growth and vary from one crop to another. So does the risk of epidemics and ideally, so should do the farmer's response (e.g. avoid spraying pesticides when this risk is low).

The biomechanics of plant leafs has been mostly studied in response to gravitation and aerodynamic loading [2]. By contrast, very few studies consider the response of a leaf to the impact of a drop [3]. If displacements were small, the long-term response would be a linear superposition of eigenmodes. However, only the short-term large displacements do matter to the liquid break-up [1]. Several modes of bending and twisting are involved. The response strongly depends on the impact point, the leaf shape, or the presence of ribs.

The master's student will first observe the high-speed dynamics of real leaves under impact. He/she will then combine theoretical modeling and experiments on artificial leaves to rationalize this short-term response. The final goal is to provide a methodology, and possibly a criterion, to characterize the response of a leaf, and later to study its influence on break-up.

References

[1] T. Gilet and L. Bourouiba, *Fluid fragmentation shapes rain-induced foliar disease transmission*, **J. R. Soc. Interface 12**, 20141092 (2015)

[2] L. Tadrist, *Mécanique du feuillage en vent: approche multi-échelle et conséquences biologiques*, Thèse de l'**Ecole Polytechnique**, Université Paris Saclay (2015)

[3] D. Soto, A. Borel De Larivière, X. Boutillon, C. Clanet and D. Quéré, *The force of impacting rain*, **Soft Matter** 10, 4929 (2014)