Study of pesticide retention on leaves using high-speed imaging

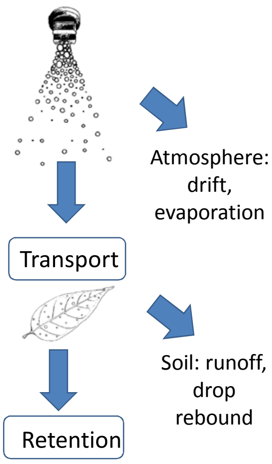
M. Massinon, F. Lebeau

Unité de Mécanique et Construction, Département des Sciences et Technologies de l'Environnement, ULg – Gembloux Agro-Bio Tech
Passage des Déportés, 2 – 5030 Gembloux, Belgium. Email: m.massinon@ulg.ac.be

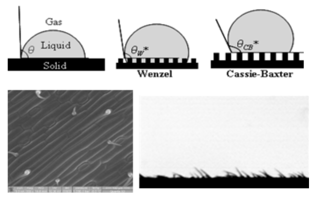
Introduction

Spray retention on leaves is a critical stage in pesticide application since losses lead to environmental and health problems. Retention is defined by the amount of product captured by the plant. The challenge is to further improve its efficiency and emphasis is placed on fundamental understanding of the mechanisms involved. Retention is determined by drop size and velocity, liquid physicochemical properties, leaf orientation and wettability. Some species, such as black-grass or wheat, are very difficult-to-treat or superhydrophobic. It originates from a high surface micro-roughness of the hydrophobic surface material.

Agrochemicals manufacturers are still interested to clarify relationships between pesticide application methods and formulation physicochemical properties on retention to guide their technical developments. Therefore an experimental screening method is proposed to analyse the physics of retention at the drop scale level in controlled and realistic conditions.



Theory

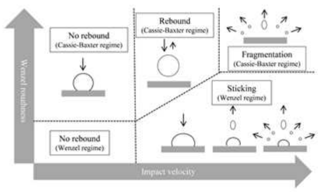


Two models describe the wetting of superhydrophobic surfaces:

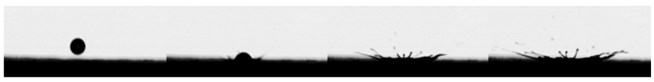
- *Wenzel regime (pinning regime)*: the liquid penetrates in the surface roughness. Static contact angle (ϑ) is low.
- *Cassie-Baxter regime*, the liquid stands on the top of the roughness. SCA is high.

The Wenzel roughness is defined as the ratio of true area of the solid surface to the apparent area.

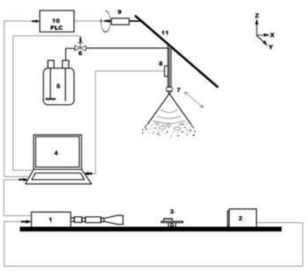
Accordingly, a drop hitting a superhydrophobic surface exhibits different behaviour as a function of the wetting regime and its energy. The Weber number which represents the ratio between the drop kinetic energy and the drop surface energy is a relevant indicator of the drop energy level at impact: $We = \frac{\rho V^2 d}{\sigma}$ where ρ is the liquid density, V is the drop velocity, d is the drop diameter and σ the liquid surface tension.



For both low *We* number and Wenzel roughness, the drop sticks on the surface. By progressively increasing the *We* number, the drop is fragmented. A part of the drop sticks at the impact point in Wenzel regime while the rest leaves the surface. At higher Wenzel roughness, the drop is either deposited, rebounds or completely splashes.



Material and Method

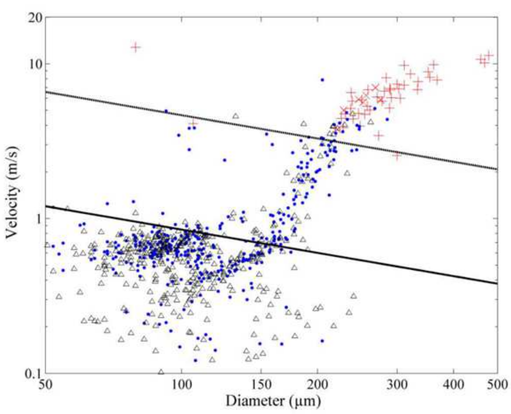


The dynamic spray application bench is composed of: (1) high-speed camera, (2) LED lightning, (3) target surface on linear stage, (4) Computer, (5) Pressurized tank, (6) Solenoid valve, (7) Nozzle, (8) Pressure gage, (9) Servomotor, (10) Programmable controller, (11) Linear stage. Excised leaf is stuck on a microscope slide with a double sided tape. The latter is placed on the linear stage to adjust its position in the camera focalization plane.

Data extraction relies on image analysis procedure, identification and selection of sharp drops is based on application of two successive thresholds. Impact types are encoded by the operator. The Weber number of transition is determined by the intersection between Weber number probability density distributions of the different impact outcomes.

Results

Results are summarized in a double log graph drop velocity as a function of drop diameter. Each symbol represents a drop impact. The sigmoid shape of the scatter plot is representative of an agricultural nozzle spray pattern. Impact outcomes: Δ adhesion, • rebound, × pinning fragmentation and + complet fragmentation. Straight lines represent transitions between impact outcomes and are constant Weber numbers.



Conclusions

The method integrates of all variables involved in a single trial, the production of the realistic drop distributions leading to the onset of all impact types and the use of dimensionless number transitions forecast between these impact outcomes. Retention can be assessed through an understanding of physics of drop impact.

Acknowledgements

This research is funded by Service Public Wallonie DG06 in the frame of the EUREKA project 4984 VEGEPHY.