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Assessment of pesticide application method efficiency by high-speed image analysis

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Context

- High pressure to decrease application rates of the remaining approved active substances used in crop protection

- Global trend to reduce volume per hectare applied to increase productivity

➔ The challenge is to maintain the current treatment efficacy in this context, so field trials are performed to guide farmers

Context – blackgrass weeding (2010)

Alopecurus myosuroides HUDS. (ALOMY)

ARVALIS Institut du végétal

	Settings			Efficacy (%) compared to a control		
	Nozzle (Teejet®)	Pressure (bars)	Nozzle forward speed (km/h)	Full dose	Half of dose	Quarter of dose
65 l/ha	XR110015	1,5	7,7	99	97	75
150 l/ha	XR11002	2	5,2	99	72	45

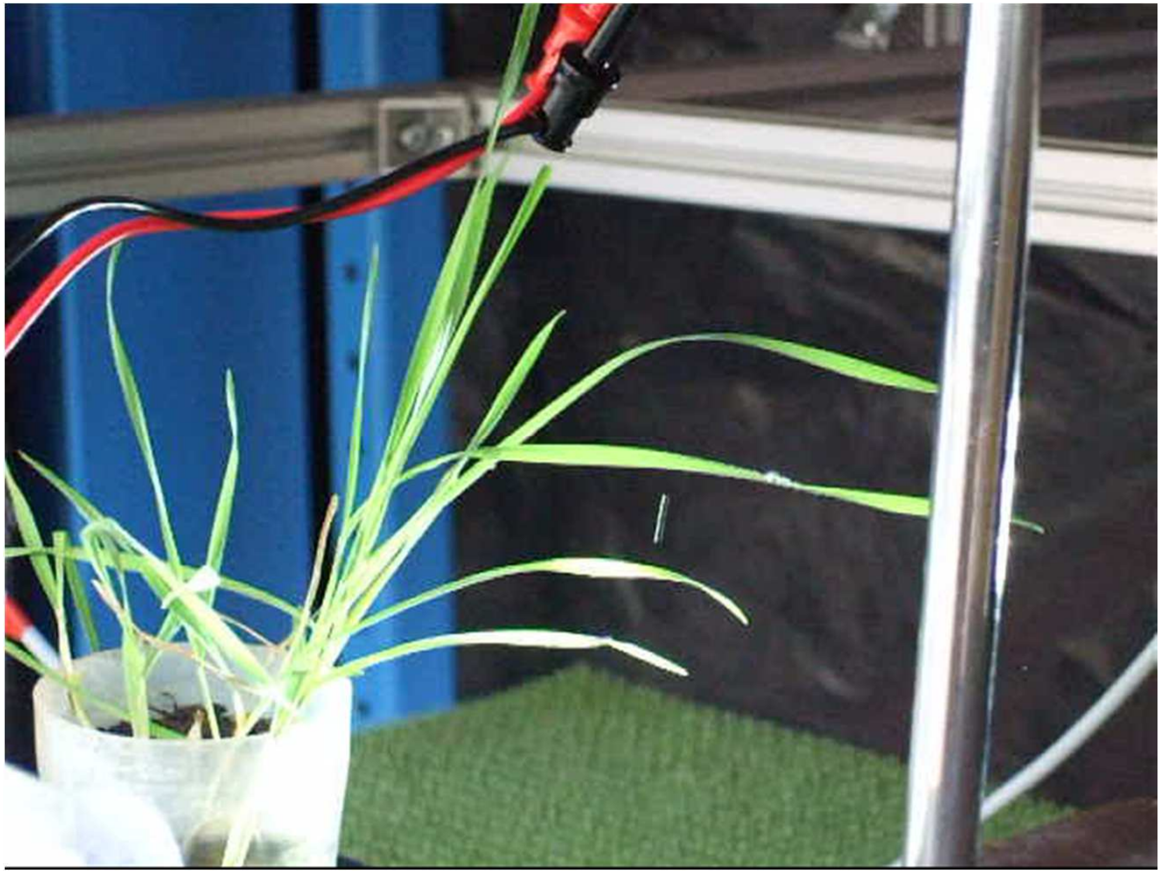
- Herbicide formulations: Archipel® (sulfonylureas, OD, Syngenta®, 125 g/ha) + Actirob®B (méthyl ester, Bayer®, 1 l/ha)

- An explanation may lie on the theories of drop impacts on very-difficult-to-wet targets or **superhydrophobic surfaces**

Perriot, B. et Thierry, D. (2011). Réduction des volumes en désherbage. *Perscpectives Agricoles,* 10-14 (in french)

Difficult-to-wet targets: superhydrophobicity

- Very difficult-to-wet species with thin leaves such as blackgrass are amongst the most challenging targets for efficient pesticide application because of superhydrophobicity



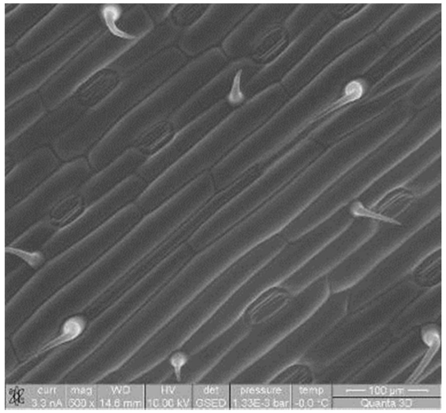
What is superhydrophobicity?

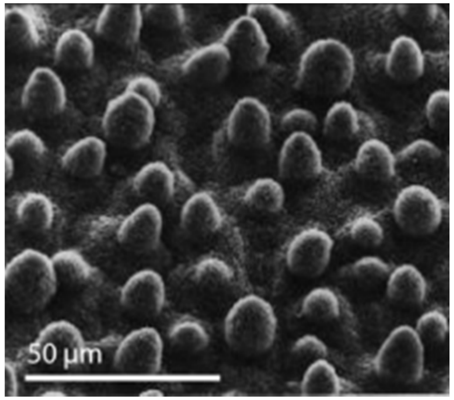
- Superhydrophobicity may appear on an hydrophobic material when its small scale roughness is increased

- Plants develop this strategy by means of waxes, hairs,… to stay clean!

- Extremely low wetting (Lotus effect)

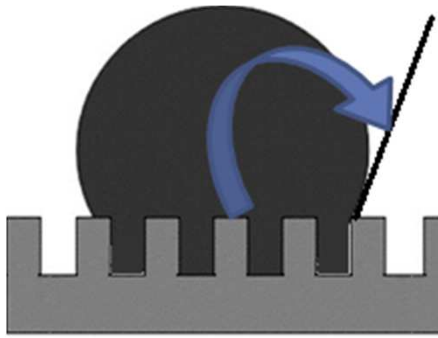
- Worst conditions for the application of water-based formulations



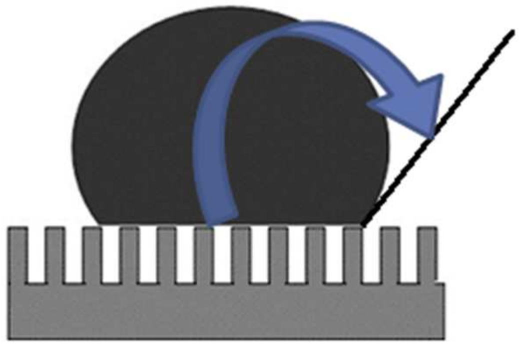


Superhydrophobicity wetting models

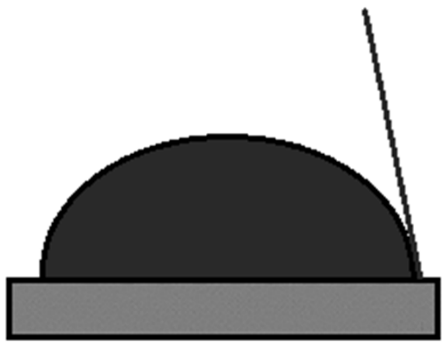
- The **Wenzel** non-composite regime also referred as pinning, characterized by the sticking of the liquid which is anchored in the surface cavities



- The **Cassie-Baxter** composite regime, where the liquid stands on the pillars of the surface and on an air film trapped beneath the drop, contact angle is higher



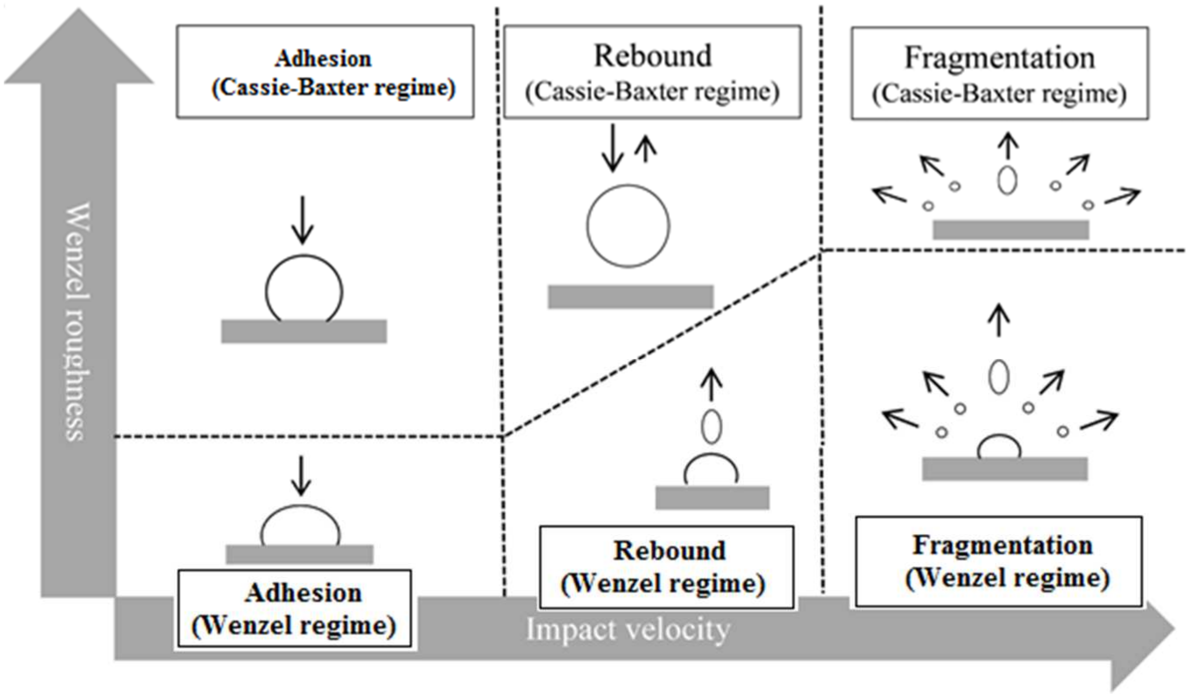
- Young model (Smooth surfaces)



Impact outcomes on a superhydrophobic surface

- But different outcomes after drop impact have been identified on such surfaces depending on the drop energy at impact (Weber number) and surface roughness (wettability)

- Because of high drop kinetic energy (impact pressure) and/or reduced surface tension, the drop may undergo a transition between these two regimes



Dimensionless Weber number

$$\frac{kinetic\ energy}{surface\ energy}$$

$$We = \frac{\rho V^2 d}{\sigma}$$

Objectives

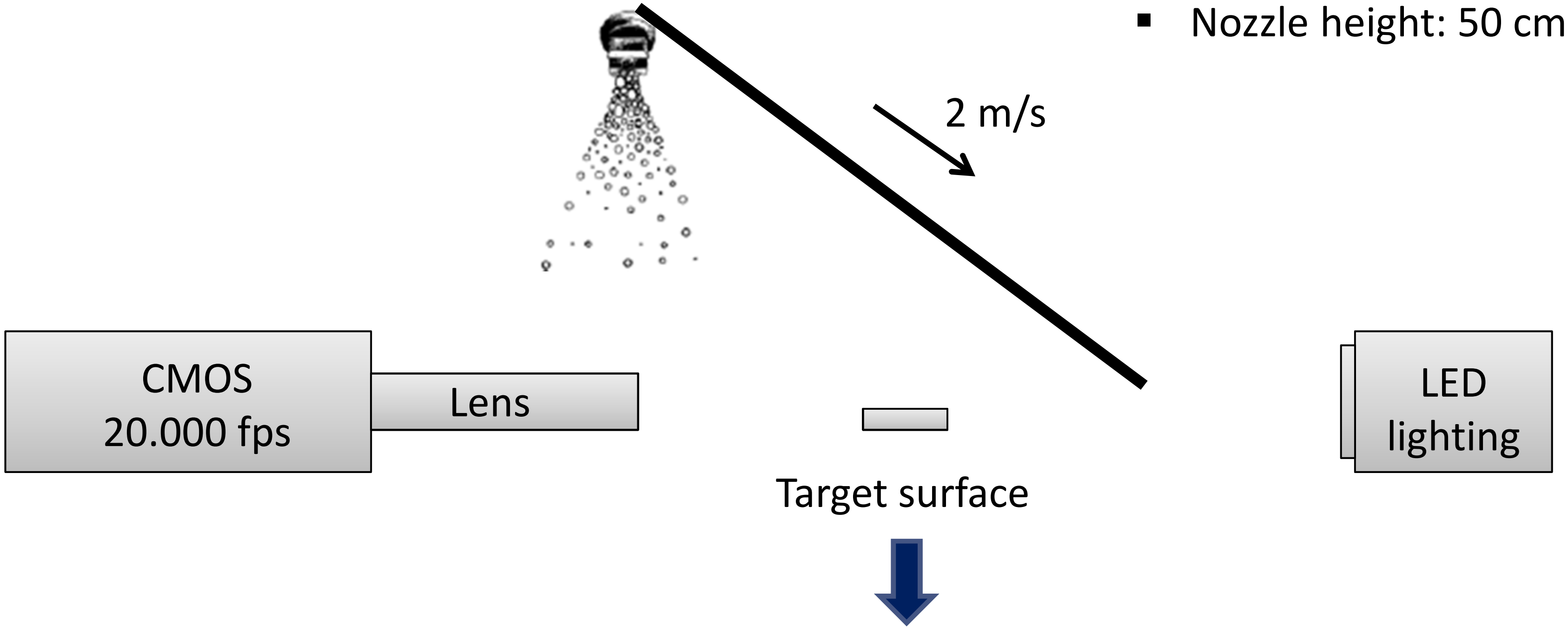
- On this basis, the aim is to know if the higher blackgrass weeding efficacy observed in field trials at reduced volume per hectare (half of dose) may be related to an increase of the efficacy of the application method

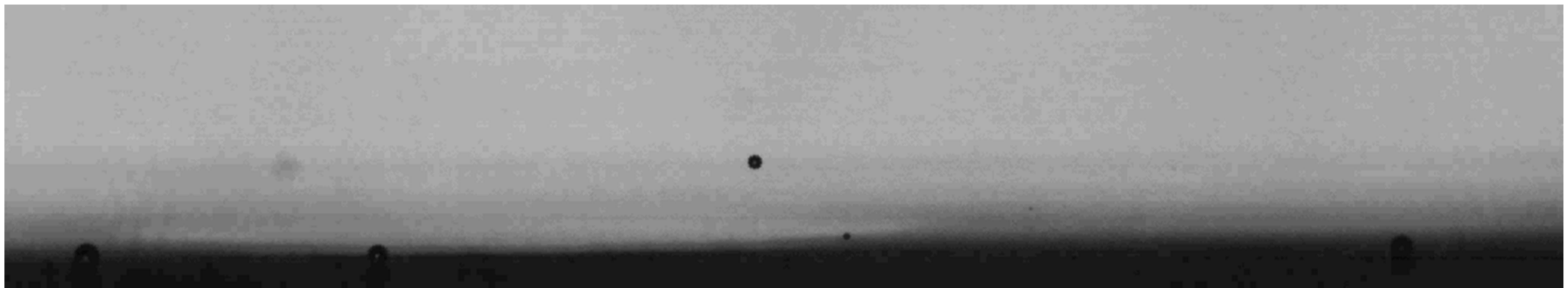
- To support this objective, the application method efficacy is assessed in laboratory by the impact characterization which governs retention on plant (amount of spray retained by the plant)

- Ten replicates (sprayings) were performed at half of the dose for both volumes. A third trial has also been performed with adjuvants to highlight their effect.

Dynamic spray application bench

- Nozzle height: 50 cm



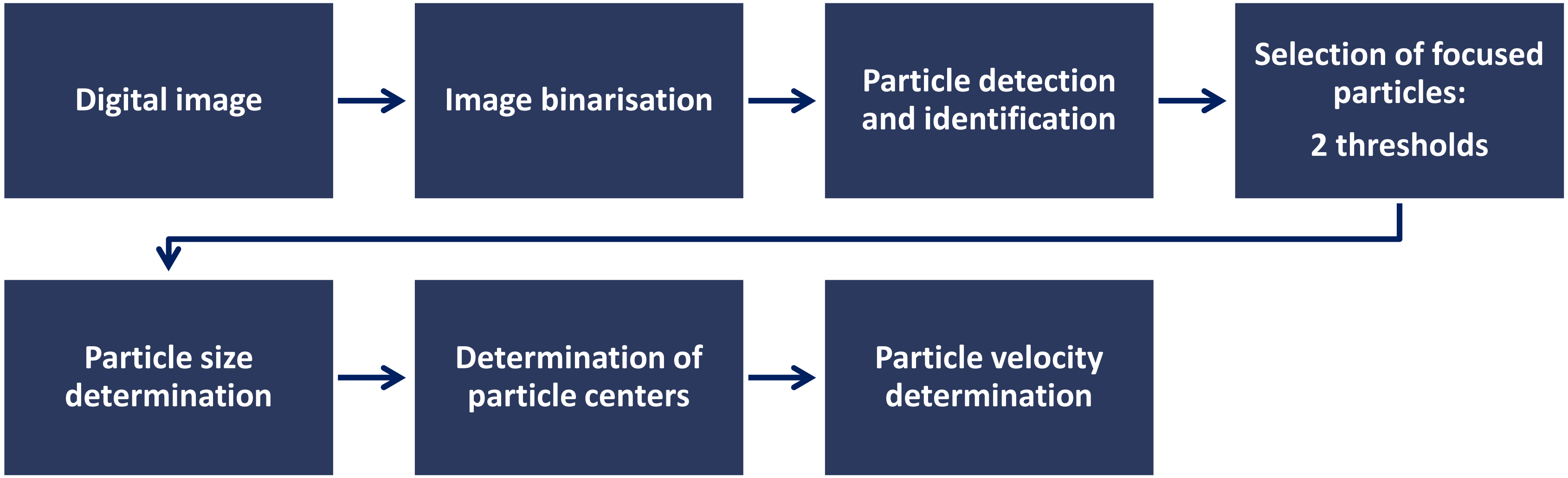


Massinon, M., Lebeau, F. (2012). Experimental method for the assessment of agricultural spray retention based on high-speed imaging of drop impact on a synthetic superhydrophobic surface. *Biosystems Engineering* 112, 56-64.

Particle Shadow Velocimetry - Spray and impact characterization

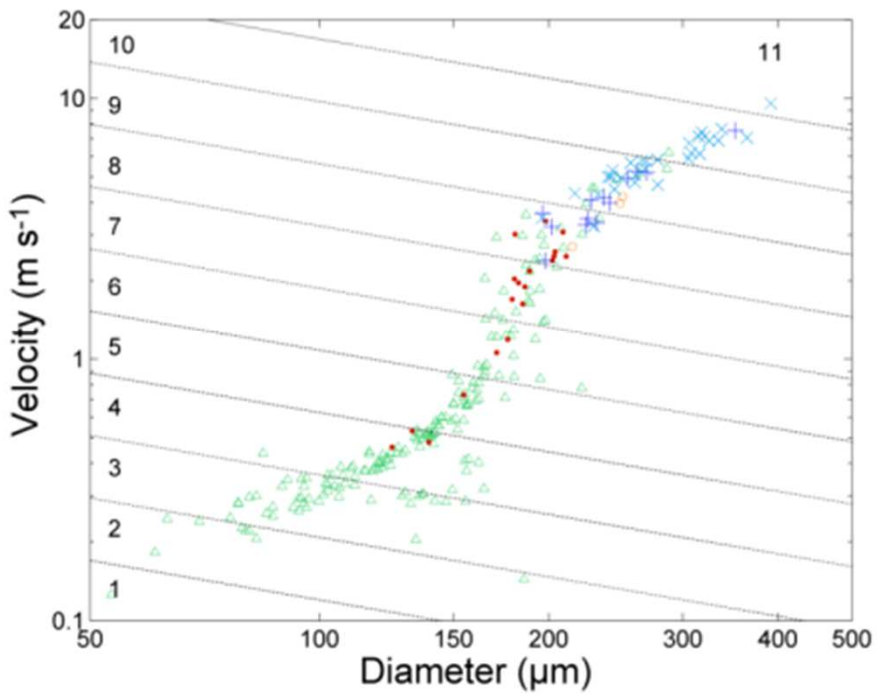
- Light extinction due to the passage of particles between camera and lighting → images with shadows of particles

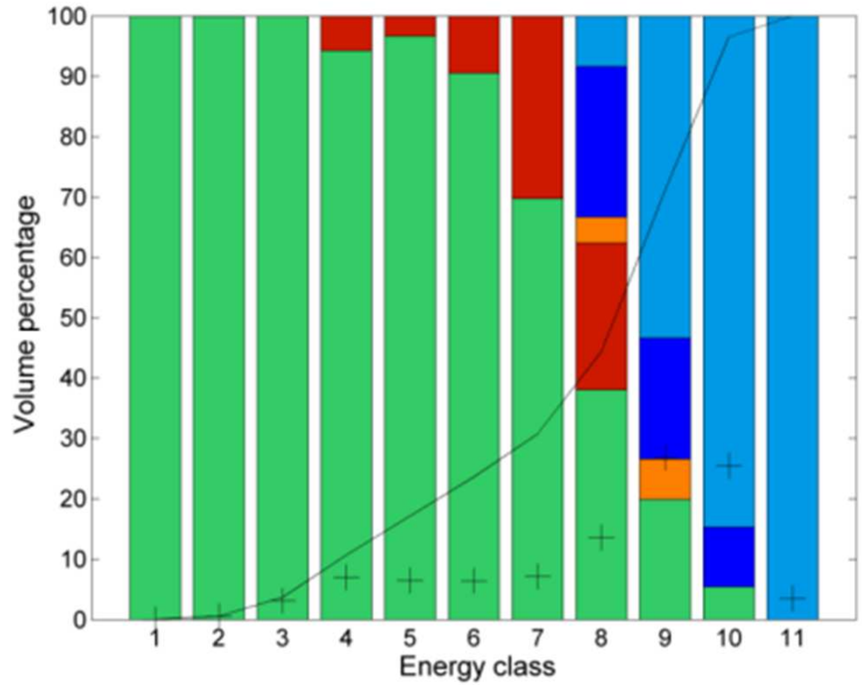
- Image processing to get a measurement of drop speed and size before impact (Matlab®)



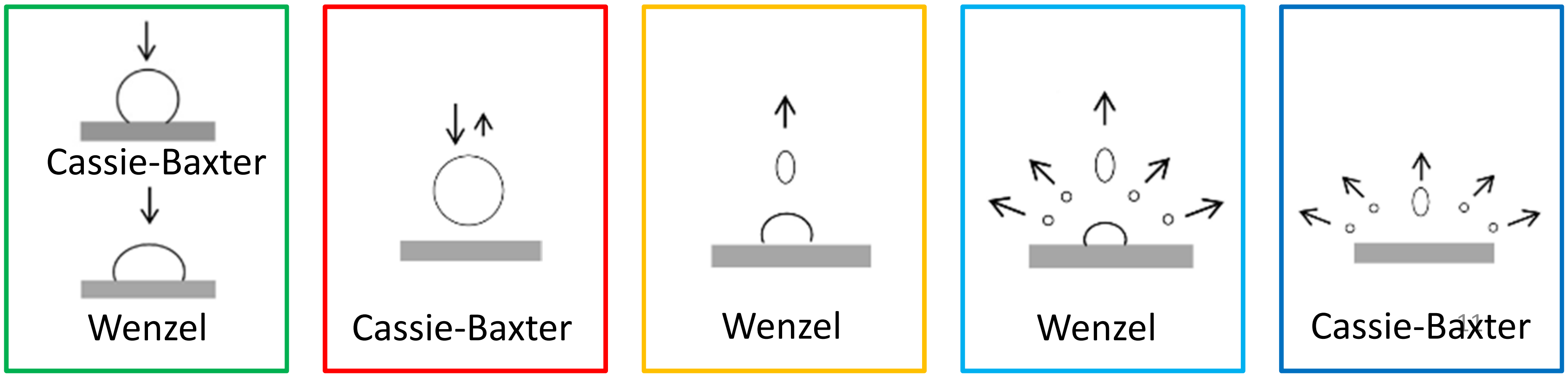
- The operator identifies the impact outcome according to the physical classification

Results – 150 l/ha

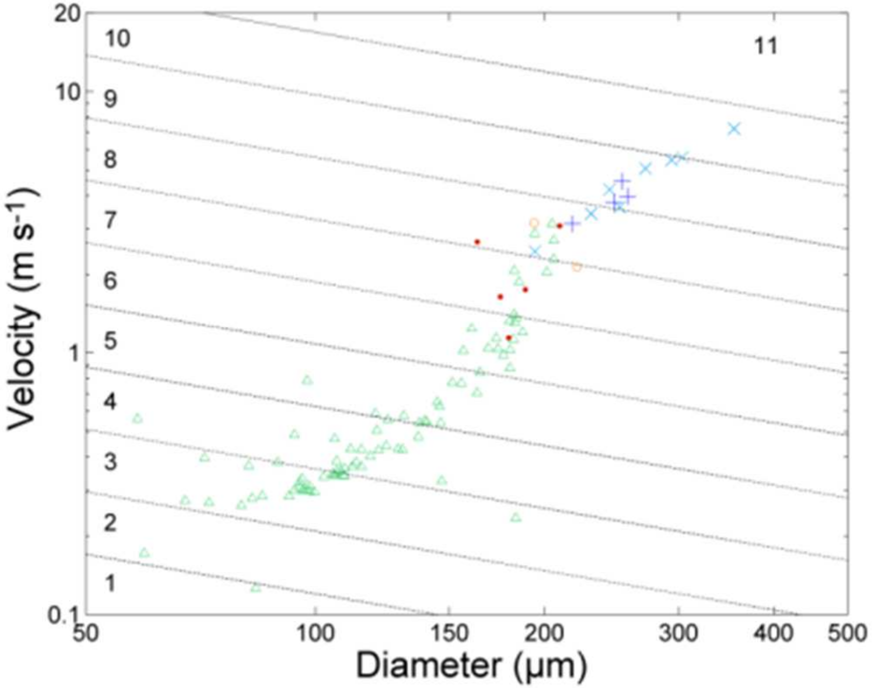


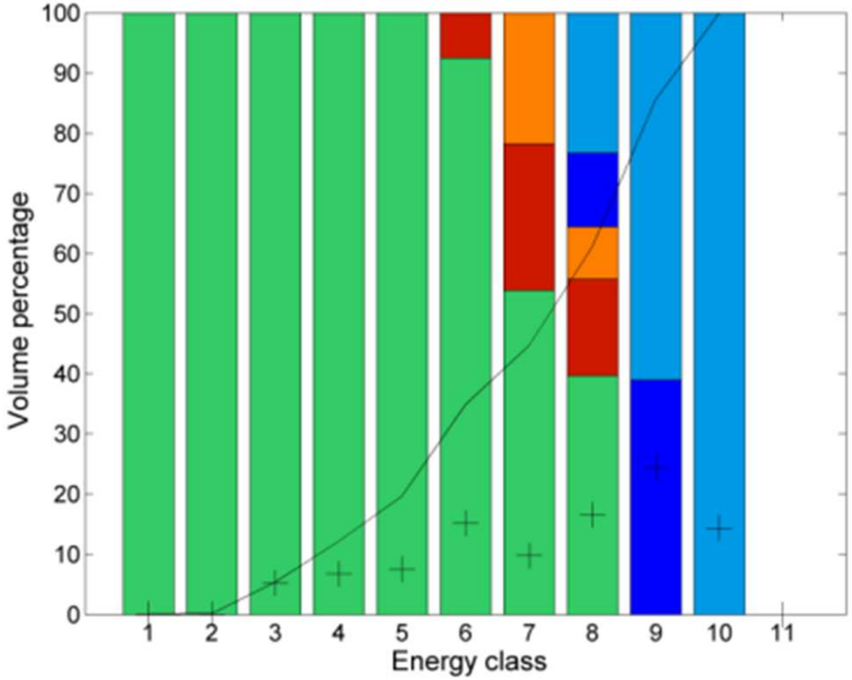


248 drops (0,893 μl)



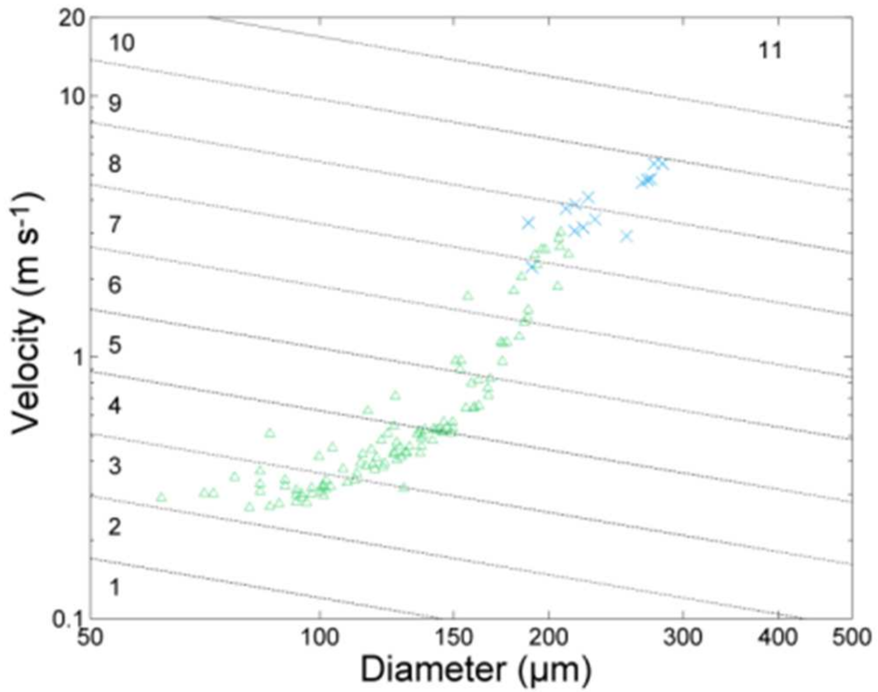
Results – 65 l/ha

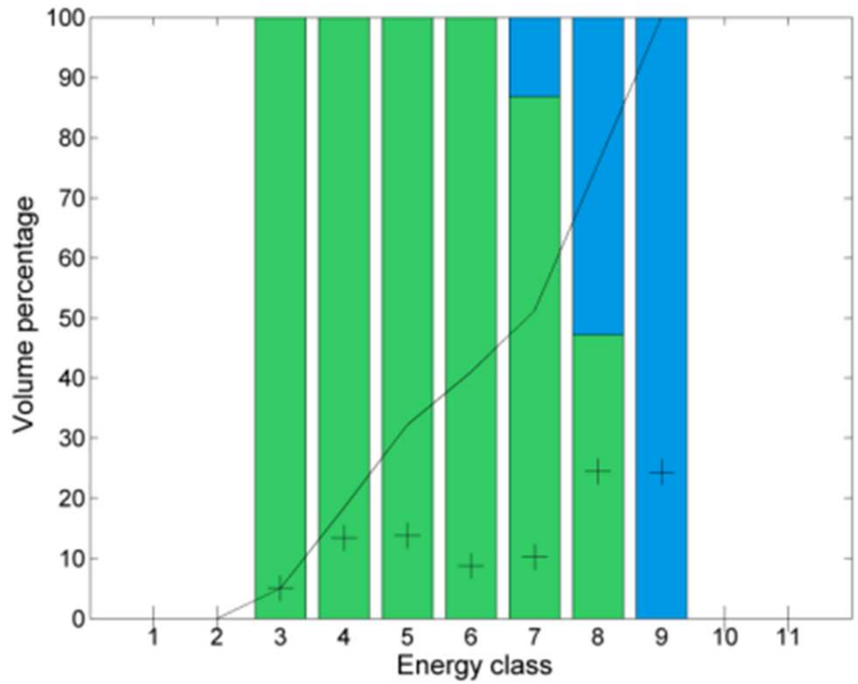




100 drops (0,259 µl)

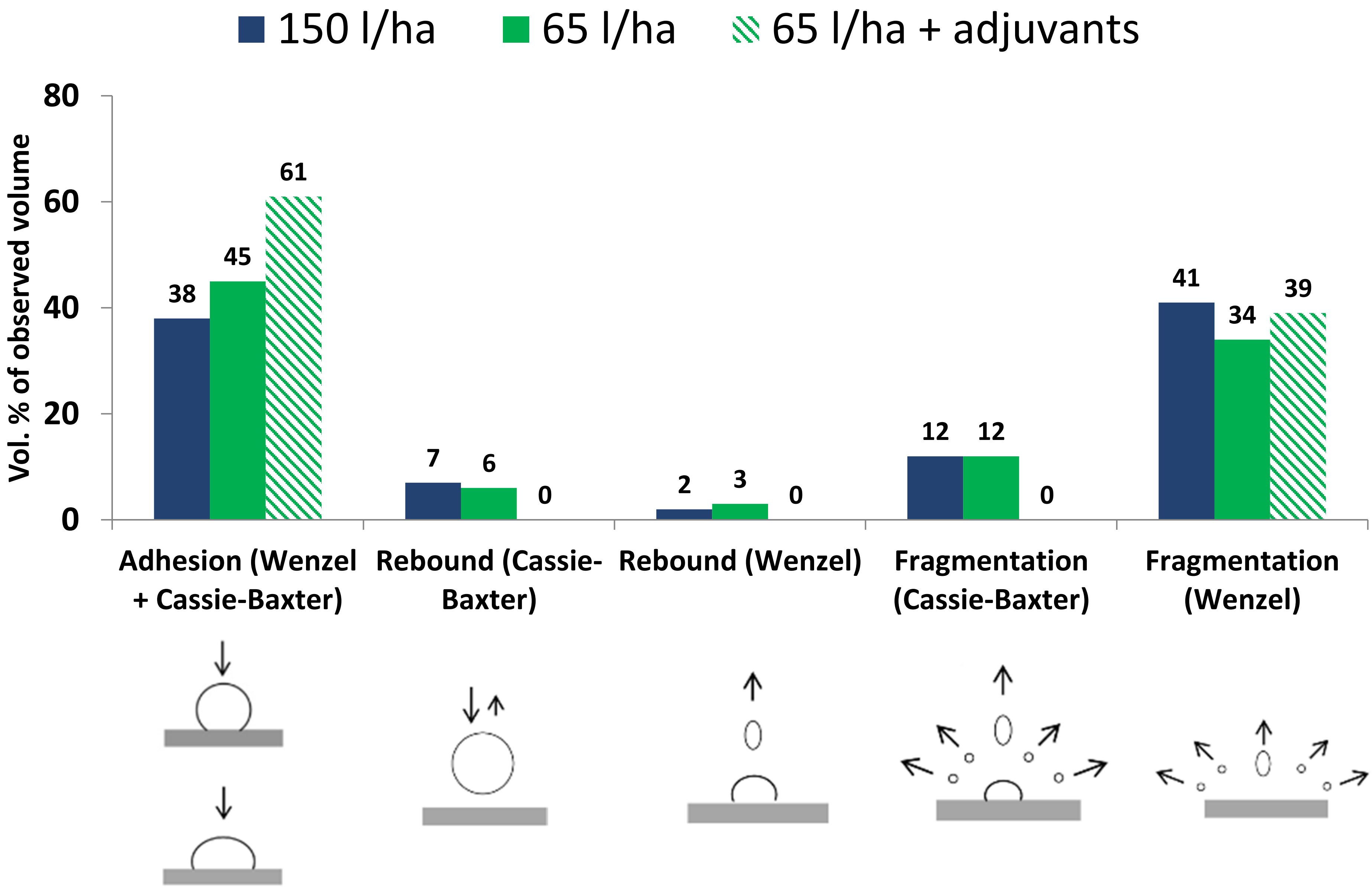
Results – 65 l/ha + Epsotop® (1%) and Heliosol® (0,5%)





122 drops (0,265 µl)

Results – Impact volume proportions



Discussion (1/2)

Reduced volumes → Drop size and velocity modification → Impact proportion modification → Retention modification → Efficacy improvement

- Increased efficacy observed in field trials at 65 l/ha is consistent with the increased retention observed in laboratory because of the drop size reduction due to the smaller pressure and nozzle calibre
- Effect of adjuvant on retention is far higher than the effect of volume
- Efficiency improvement at reduced volume was not observed anymore in 2011

Discussion (2/2) – Thank you for your attention

- Response to the volume depends on numerous parameters such as plant sensibility to active substance, it remains difficult to explain field observations using a single variable such as retention

- However it’s a the first attempt to rely field trials with impact studies

- The method offers an insight of the complex interactions between droplets, target and formulation physicochemical properties

- The method can be used ahead to guide the design of more discriminant tests for other assessment methods

- The method is suitable for ranking formulation effect on retention