Giuseppe Pellizzi Prize

CLUB OF BOLOGNA

Towards a sustainable use of plant protection products in orchards: Implementation of canopy-adapted spray technology and new developments for spray efficiency evaluation

Dissertation presented to University of Universitat Politècnica de Catalunya, Barcelona, Catalunya, SPAIN

LU XUN

Department of Agri-Food Engineering and Biotechnology,

Universitat Politècnica de Catalunya, Barcelona , SPAIN

✉: lu.xun_echo@qq.com ☎: +8619327876609

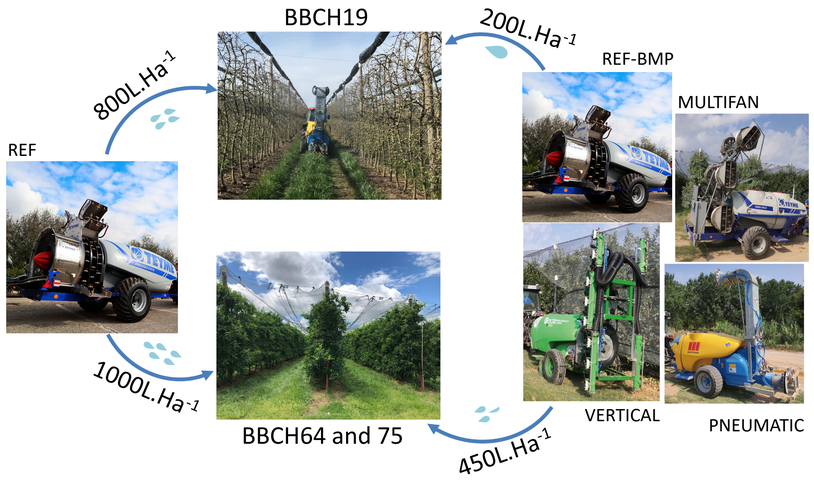
1 Introduction

For the conventional application of plant protection products (PPP), farmers normally tend to overdose spray to assure biological efficacy with inadequate sprayer adjustments. This practice produces huge off-target losses, leading to the waste of PPP and adverse effects on human health and the environment. To address this issue, the appropriate dosage of PPP was expected to be evenly distributed to the target with high efficiency and effective biological efficacy to achieve a good spray application. However, there are great difficulties and challenges to achieve it for spray application in orchards because of the large variability in canopy structure and volume. These variations can result from many factors such as crop type, training system, pruning method and growth stage. Furthermore, there is also remarkable intra-orchard variability in canopy characteristics at a specific time due to soil characteristics, topography, and microclimate. In addition, for the spray quality evaluation with water sensitive papers, the handling of overlapping droplets remain to be solved to obtain more accurate spray quality indicators (deposition density and droplet size spectra).

In this context, the main objective of this doctoral thesis is to improve spray applications in orchards from two major aspects: a) to evaluate and quantify the potential improvement of canopy-adapted spray technology in PPP use, spray quality and biological efficacy through field tests, and b) to develop new methodologies for spray quality evaluation.

2 Optimized spray application to match overall canopy characteristics

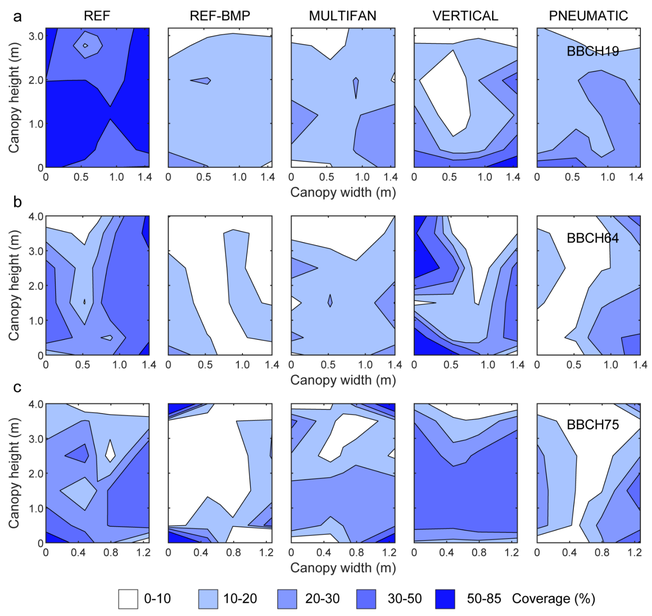
Experimental design



Droplet distribution evaluation

Biological efficacy evaluation

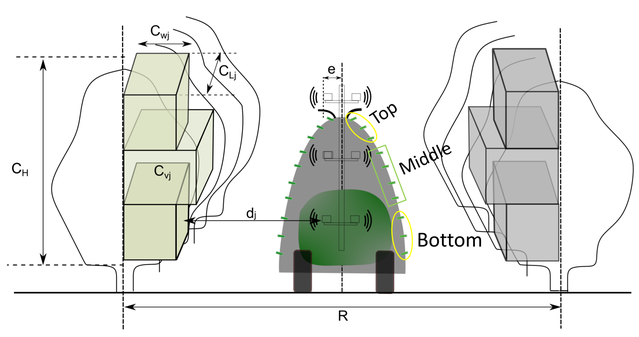
Key results

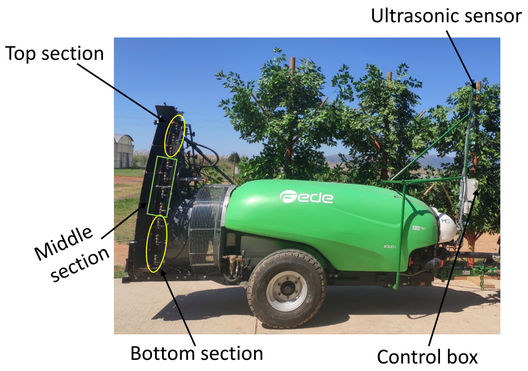


- A suitable setting and adjustment of the sprayer can contribute to a consistent spray quality throughout the entire growth stage.
- The optimized low-volume applications adapted to the tree canopy can greatly reduce the pesticide use (75% reduction for the early stage and 50% reduction for the middle and late stage), while maintaining effective control of pests and diseases.
- The sprayer type can directly affect droplet distribution within the tree canopy, and the orchard sprayer equipped with vertical booms and the pneumatic sprayer demonstrate their advantages.

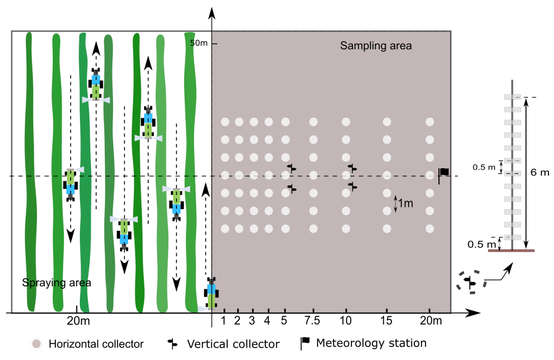
3 Variable rate application to match the intra-orchard variation

Developed variable rate sprayer

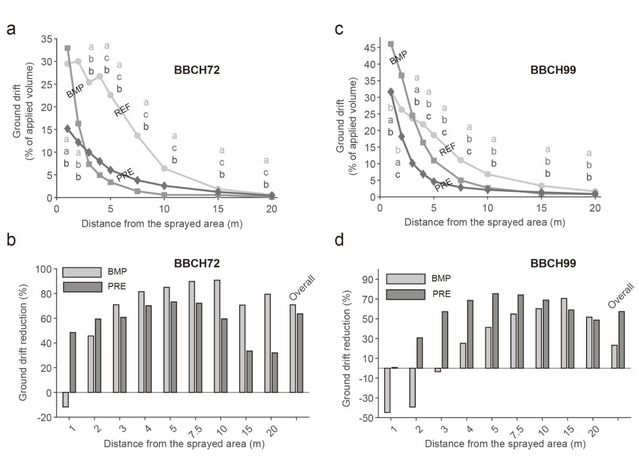




Field tests of spray drift



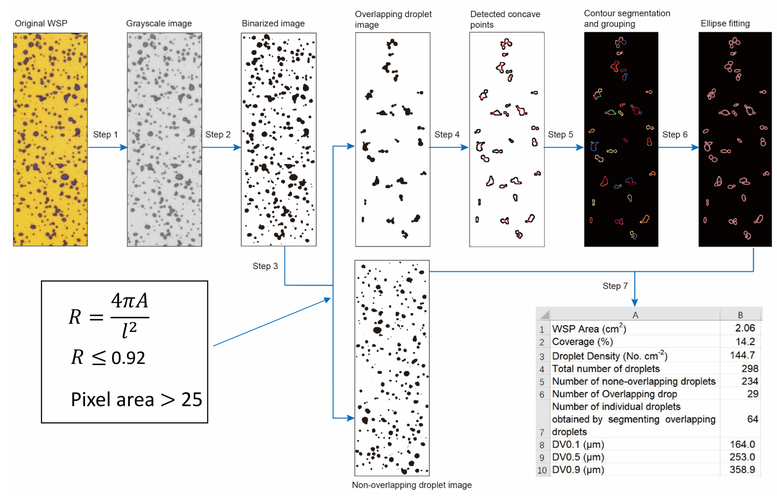
Key results



- Compared to the conventional application, the other two advanced applications can significantly reduce the ground drift (23.3–70.9%) and airborne drift (26.2–84.6%).
- The precision application showed a remarkable advantage in drift reduction for the sparse canopy.
- The saving of applied pesticide was achieved by 12% with the optimized application and 43% with the precision application.

4 A novel methodology for water-sensitive papers analysis

Proposed methodology

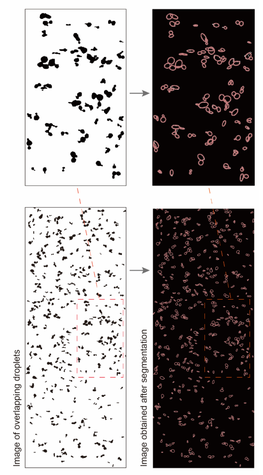


$$R = \frac{4\pi A}{l^2}$$

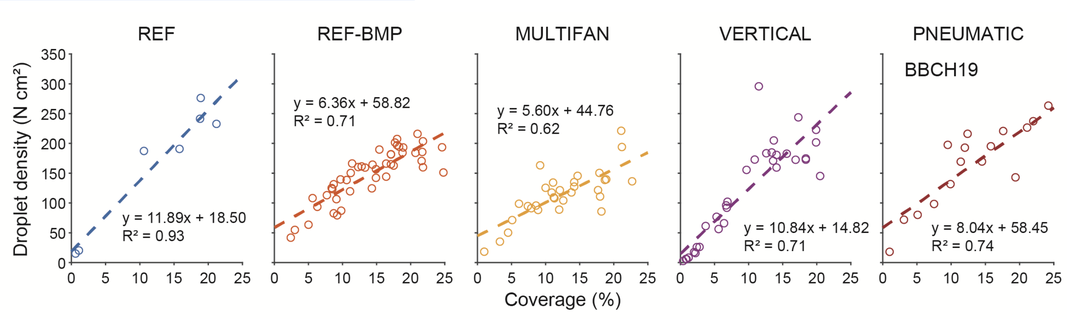
$R \leq 0.92$

Pixel area > 25

	A	B
1	WSP Area (cm^2)	2.06
2	Coverage (%)	14.2
3	Droplet Density (No. cm^{-2})	144.7
4	Total number of droplets	298
5	Number of none-overlapping droplets	234
6	Number of Overlapping drop	29
7	Number of individual droplets obtained by segmenting overlapping droplets	64
8	DV0.1 (μm)	164.0
9	DV0.5 (μm)	253.0
10	DV0.9 (μm)	358.9



Key results



- For the water-sensitive papers with coverage below 25%, the proposed methodology achieved a high overall segmentation accuracy of 77.8%, which allowed to precisely characterize the corresponding deposition pattern.
- A universal linear relationship was observed between the droplet density and coverage, independent of the sprayer and canopy characteristics.

5 General conclusions

In most cases, the canopy-adapted application with highly reduced PPP achieved equal or better spray quality within the tree canopy and remarkably lower spray drift than the conventional application while maintaining the effective control of pests and diseases. The canopy-adapted technology can effectively reduce the use of PPP in orchards and promote the sustainable use of PPP. In addition, the proposed methodology to analyze water-sensitive papers allow to obtain more accurate spray quality indicators and can be widely used for spray application evaluation to promote precision spraying.