FEDER UNACOMA
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Accademia dei Georgofili

Giuseppe Pellizzi Prize 2018

[F] PhD Extended Abstract Form

Strategies for the optimization of the efficiency in the plant protection product applications in olive canopies

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Extended Abstract

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Pesticide application in olive is still performed in a very rudimentary way, without consistent scientific fundamentals to support it. This circumstance is especially important in treatments aiming the tree crown, as its three-dimensional and irregular shape makes it very difficult to uniformly cover it with the spray plume coming from the spraying equipment. In addition, the contact action in the copper salt-based fungicides commonly used to control the olive leaf spot (*Spilocaea oleagina*), the main disease affecting the crop, lead farmers to dramatically increase the application water volumes – and therefore the pesticide dose – to completely cover the entire canopy in order to guarantee the biological efficacy of the treatment by preventing the germination of the fungus spores with the copper presence. This fact generates important product losses that represent risks for the applicator and the environment.

In order to improve the current situation and to accomplish the sustainability requirements imposed by the new regulatory framework and by consumers and citizens, who are getting more and more sensible to this kind of problems, there are three main lines on which advances should be done: optimization of the operational parameters, tree crown characterization methodologies plus proportional dosing systems and the application machinery.

The lack of research makes difficult to know the influence of the main spray variables on the treatment quality. Among them, the liquid volume and the airflow rate are the ones more easily adjustable by the farmer, who tends to maximize their values to improve the leaf coverage and the penetration of the product inside the tree crown. However, there is no scientific evidence supporting this popular belief and, on the contrary, the widespread practices produce important pesticide losses as spray drift and runoff.

On the other hand, olive growers lack a simple and adapted dosing system which allows them to have any reference of the suitable water volume to be applied according to the geometric characteristics of the trees. Olive is a perennial crop and, therefore, the main parameter to be considered is the tree crown volume. Nevertheless, there is no information on the accuracy of the manual methods for canopy characterization most commonly used, so there is no certainty about the real possibility of establishing a dosing system based on manual canopy characterization methods. Electronic methods, even being much more accurate than the manual ones, are still far from being used by regular farmers due to their complexity and need of specific training they involve.

Last, the most widespread equipment in olive canopy treatments, the airblast sprayer, is highly inefficient because it is conceived for regular low-sized trees with no space in-between the trees. The development of new sprayers adapted to the particular conditions of olive orchards would allow farmers to reduce thee applied pesticide doses and to increase the biological efficacy by generating more regular deposition patterns, reducing the operation cost and making possible to reach the sustainability and the food security.

1. Chapter 1.

Paper: Miranda-Fuentes et al., 2015. Influence of liquid-volume and airflow rates on spray application quality and homogeneity in superintensive olive tree canopies. Science of the Total Environment, 537: 250–259.

Operational parameters must be optimized to increase the efficacy and efficiency of pesticide applications in olive canopies. The aim of this work was to assess the influence of the liquid volume and the airflow rate on the spray deposition and coverage in different parts of the canopy in a superintensive olive orchard. It was also an objective to study the effect of the relationship between both parameters on the same indicators of the treatment quality.

Two spray experiments using a commercial airblast sprayer were conducted in a superintensive orchard to study how varying the liquid volume rate (testing volumes of 182, 619, and 1603 l ha^{-1}) and volumetric airflow rate (with flow rates of 11.93, 8.90, and 6.15 m^3 s^{-1}) influences the coverage parameters and the amount and distribution of deposits in different zones of the canopy.

Our results showed that an increase in the application volume raised the mean deposit and percentage coverage, but decreased the application efficiency, spray penetration, and de- posit homogeneity. Furthermore, we found that the volumetric airflow rate had a lower influence on the studied parameters than the liquid volume; however, an increase in the airflow rate improved the application efficiency and homogeneity to a certain threshold, after which the spray quality decreased. This decrease was observed in the high-flow treatment. Our results demonstrate that intermediate liquid volume rates and volumetric airflow rates are required for the optimal spraying of pesticides on super-intensive olive crops, and would reduce current pollution levels.

2. Chapter 2

Paper: Miranda-Fuentes et al., 2015. Towards an optimized method of olive tree crown volume measurement. Sensors, 15: 3671–3687.

Accurate crown characterization of large isolated olive trees is vital for adjusting spray doses in three-dimensional crop agriculture. Among the many methodologies available, laser sensors have proved to be the most reliable and accurate. However, their operation is time consuming and requires specialist knowledge and so a simpler crown characterization method is required. To this end, three methods were evaluated and compared with LiDAR measurements to determine their accuracy: Vertical Crown Projected Area method (VCPA), Ellipsoid Volume method (V_E) and Tree Silhouette Volume method (V_{TS}). Trials were performed in three different kinds of olive tree plantations: intensive, adapted one-trunked traditional and traditional. In total, 55 trees were characterized. Results show that all three methods are appropriate to estimate the crown volume, reaching high coefficients of determination: R^2 = 0.783, 0.843 and 0.824 for VCPA, V_E and V_{TS}, respectively. However, discrepancies arise when evaluating tree plantations separately, especially for traditional trees. Here, correlations between LiDAR volume and other parameters showed that the Mean Vector calculated for VCPA method showed the highest correlation for traditional trees, thus its use in traditional plantations is highly recommended.

3. Chapter 3

Paper: Miranda-Fuentes et al., 2016. Assessing the optimal liquid volume to be sprayed on isolated olive trees according to their canopy volume. Science of the Total Environment, 568: 296–305.

The aim of this study was to determine the optimal relationship between canopy volume and the spray application volume, called specific spray volume, C_V, through laboratory and field trials. In the laboratory trial, 6 specific spray volumes (0.05, 0.08, 0.10, 0.12, 0.15, and 0.20 L m^{-3}) were tested in a specially designed structure containing small, live olive trees in order to simulate an intensive plantation system. The model aimed to evaluate the coverage of pesticide application on water sensitive paper (WSP) collectors. In the field trial, the three laboratory specific spray volumes that gave the best coverage values were tested on live, intensively managed trees, whose crown volume was manually measured. Food dye E-102 was used to determine the spray deposition on artificial targets (10 × 10 cm absorbent paper pieces), and WSP was used to evaluate spray coverage. The spray penetration and deposit homogeneity inside the canopy were also evaluated. Weather conditions during the field trial were monitored with a weather station. The results of the laboratory trial showed that the three best specific spray volumes were 0.08, 0.10, and 0.12 L m^{-3}, resulting in mean coverage values of approximately 30%. The ANOVA of the field trial results showed that the 0.12 L m^{-3} was the optimal specific spray volume for isolated olive trees. This specific spray volume gave the highest mean deposits, the best efficiency (as measured by the greatest normalized deposit), the most favourable penetration and homogeneity, and the highest coverage values.

4. Chapter 4

Paper: Miranda-Fuentes et al., 2017. Improving plant protection product applications in traditional and intensive olive orchards through the development of new air-assisted sprayer prototypes. Crop Protection, 94: 44–58.

Because of the pollution caused by inappropriate pesticide applications to olive canopies, a project was undertaken to develop new airblast sprayers to optimise application efficiency and overcome the limitations of conventional sprayers used in traditional and intensive orchards. Three prototype sprayers were developed, evaluated, and calibrated under laboratory

conditions and were tested in the field by spraying trees in traditional and intensive cultivation systems. Water-sensitive paper was used to assess the spray coverage achieved. The prototype sprayers were designed to adapt the deposition nozzle positions to the canopy shape to reduce spray drift and off-target application. The first prototype (P1) consisted of a sprayer with a centrifugal fan and adaptable individual spouts, the second (P2) consisted of a sprayer with six small hydraulically-driven axial fans mounted on two mobile structures, and the third (P3) consisted of two axial fans mounted on a tower-like structure with mobile air outlets. The results of the field test showed that the prototypes could be more efficient than conventional equipment. In applying the same liquid volume, the P2 and P3 prototypes increased the coverage by 61% and 46% on average in intensive and traditional systems, respectively, compared to a commercial airblast sprayer, without a significant decrease in the deposit homogeneity throughout the crown.

Final remarks concerning the competition benchmarks and strength points

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The work included in the PhD comprise the improvement of the pesticide application in olive orchards from an integral point of view, acting on the main problems detected, with a very practical and innovative orientation. A simple and affordable dosing system is set to help farmers knowing the best configuration for their sprayer. The prototypes developed showed very good potential, and even one of them is already in the market and can be bought by farmers, with a great commercial success.