First Measurements with a Lidar System Specifically Designed for Spray Drift Monitoring

E. Gregorio[1], X. Torrent[1], F. Solanelles[2,4], R. Sanz[1], F. Rocadenbosch[3], J. Masip[1], M. Ribes-Dasi[1], S. Planas[1], J.R. Rosell-Polo[1]

[1]Departament d'Enginyeria Agroforestal, Research Group in AgroICT & Precision Agriculture, Universitat de Lleida, Lleida, SPAIN
[2]Centre de Mecanització Agrària. Generalitat de Catalunya, Lleida, SPAIN
[3]Dep. de Teoria del Senyal i Comunicacions. Univ. Politècnica de Catalunya, Barcelona, SPAIN
[4]Research Group in AgroICT & Precision Agriculture, SPAIN

Introduction

Pesticide spray drift is usually measured by means of passive collectors and tracers. However, there are several drawbacks to their use, related to the fact of being a time-consuming, single-point and time-averaged sampling methodology. Alternative methodologies are being searched in order to overcome these difficulties. In this line, lidar technology is one of the most promising alternatives since it can measure the spray drift in real-time, with high range resolution, requires little labour and low time consumption, and it does not need chemical analysis (Gregorio et al, 2014). In spite of these advantages, so far lidar systems have been used in a limited number of spray drift studies (Hiscox et al., 2006; Khot et al., 2011) due to its high cost, complexity and the fact that most systems are not eye-safe. This article compares the measurements obtained with a new lidar system specifically developed for spray drift monitoring with those obtained using passive collectors following the ISO 22866 standard.

Fig. 1. Lidar system (foreground) measuring the spray drift generated by the sprayer (background).

Fig. 2. Horizontal and vertical collectors distribution (ISO 22866), and the mirror.

Material and Methods

The spray tests were carried out between November 11 and 21, 2014, at a field site in Gimenells (41º39'11''N, 0º23'28''E, elev. 259 m) located 25 km away from Lleida, Spain. The trials were performed in an intensive apple orchard (growth stage, BBCH:92) with tree rows at right angle to the prevailing winds (Fig. 1). The spray was generated by an axial-fan air-assisted sprayer (Teyme Eolo 2091) operating at 1 MPa. Two nozzle types were tested: standard (Albuz ATR 80 Grey) and low-drift nozzles (Albuz TVI 80-03, Blue). The sprayed volumes were 810 and 860 l/ha for the standard and for the low-drift nozzles, respectively. The spray liquid was an aqueous solution of brilliant sulfoflavine. For the measurement of ground drift, filter papers (horizontal collectors) were placed every 2.5 m up to 20 m downwind from the last tree row and every 5 m from 20 to 40 m. For the measurement of airborne drift, 6-m height nylon lines (vertical collectors) were placed at 5 and 10 m downwind. Also, water-sensitive paper sheets attached to the vertical pole at 5 m were used for measuring the airborne drift.

The lidar system is based on a 1534-nm wavelength, 3-mJ pulse-energy erbium-glass laser (Gregorio et al., 2015). It is an eye-safe system, with high range (2.4 m) and temporal (100 ms) resolution, scanning capability and easy to carry. The lidar was placed at a distance of 70 m from the trees and pointing to a mirror (45º of inclination) placed near the pole at 5 m (Fig. 2). The laser beam is emitted horizontally with a path parallel to the horizontal collectors. The mirror reflects the beam vertically so its path is parallel to vertical collectors. This experimental set up allows a simultaneous comparison of lidar measurements with both horizontal and vertical collectors.

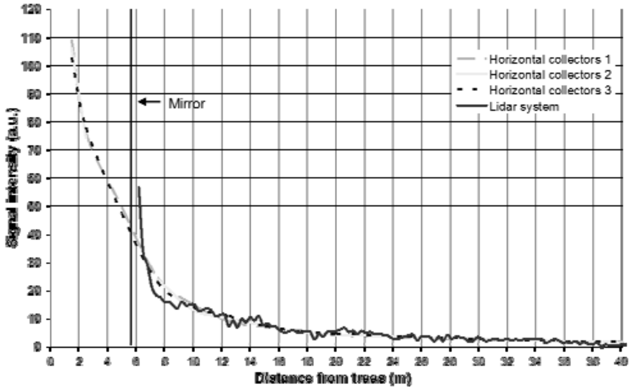

Fig. 3. Time-integrated lidar signal and tracer mass captured by horizontal collectors at each downwind distance from the last tree row (arbitrary units).

Results

Figure 3 compares the received lidar signal with the measurements carried out by horizontal collectors for a standard nozzle test. A high coefficient of determination ($R^2 \approx 0.90$) between both measurements is observed. Similar high determination coefficient figures are obtained with low-drift nozzles (not shown in the figure) while in this case the signal is lower, as was expected. It can be concluded that the lidar system is able to differentiate between both cases. Preliminary analysis demonstrates that the lidar has also measured airborne drift. Currently, data processing is being carried out in order to compare these measurements with those obtained by vertical collectors. These first results are encouraging to propose a new lidar-based methodology alternative to current ISO 22866 standard methodology with passive collectors.

Acknowledgements

This research was partially funded by the Spanish Ministry of Economy and Competitiveness (projects AGL2007-66093-C04-03, AGL2010-22304-04-C03-03 and AGL2013-48297-C2-2-R) and EU FEDER. Authors would like to thank IRTA for allowing the use of their experimental fields.

References

Gregorio E, Rosell-Polo JR, Sanz R, Rocadenbosch F, Solanelles F, Garcerá C, Chueca P, Arnó J, del Moral I, Masip J, Camp F, Viana R, Escolà A, Gràcia F, Planas S, Moltó E (2014). LIDAR as an alternative to passive collectors to measure pesticide spray drift. Atmospheric Environment 82, 83-84.

Gregorio E, Rocadenbosch F, Sanz R, Rosell-Polo JR (2015). Eye-safe lidar system for pesticide spray drift measurement. Sensors (in press).

Hiscox AL, Miller DR, Nappo CJ, Ross J (2006). Dispersion of fine spray from aerial applications in stable atmospheric conditions. Transactions of the ASABE 49(5): 1513-1520.

Khot LR, Miller DR, Hiscox AL, Salyani M, Walker TW, Farooq M (2011). Extrapolation of droplet catch measurements in aerosol application treatments. Atomization and Sprays 21(2), 149-158.