Technical solutions to reduce drift of pesticides in apple orchards of Trentino

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DOI 10.5073/jka.2012.439.026

Summary
Drift of pesticides is a critical element in achieving the plant protection management. As a phenomenon influenced by multiple factors is likely to be reduced, but not totally eliminated.
Actually in Province of Trento most growers who sprays next to drift sensitive areas (houses, roads, bicycle patches, etc.) use mainly spray lances. To mitigate drift many other technologies are available along with several techniques. On the other hand the differences between training and pruning systems, planting distances, cultivation environments, etc., must be taken into consideration to achieve the highest level of reduction. The main characteristics of the rural landscape of Trentino are: strict connection with inhabited areas, medium or steep slope of most apple plots and intensive orchard growing with height of trees up to four meters.
Comparative tests have been carried out in 2009 during different wind conditions (almost total absence and presence of wind) to verify the mitigation ability of anti-drift nozzles, used with different sprayer adjustments and coupled with other devices. Due to the instability of wind conditions during treatments, as to ensure the maximum level of drift reduction, other technical solutions were tested in 2011 and resulted adoptable together with the devices already tested.

Introduction
Drift of pesticides is a critical element in achieving the plant protection management. As a phenomenon influenced by multiple factors (Van Ee, 1998; Wolf, 2000) is likely to be reduced, but not totally eliminate. Actually in Province of Trento the most of growers who sprays next to drift sensitive areas (houses, roads, bicycle patches, etc.) uses spray lances. To mitigate drift many other technologies are available along with several techniques (Balsari et al., 2000; De Schampheleire et al., 2008; Herbst, A., 2005; Rautmann, D., 2003).
On the other hand the differences between training and pruning systems, planting distances, cultivation environments, etc., must be taken into consideration to achieve the highest level of reduction (Balsari & Marucco, 2004). The main characteristics of the rural landscape of Trentino are: strict connection with inhabited areas, medium or steep slope of most apple plots and intensive orchard growing with height of trees up to four meters.
Based on these considerations during the fruit season 2009 an experimental activity began on drift management in apple orchards. Comparative tests have been carried out during different wind conditions (almost total absence and presence of wind) to verify the mitigation ability of anti-drift nozzles, used with different sprayer adjustments and coupled with other devices. As the general impossibility to meet the requirements of ISO 22866 (Methods for field measurement of spray drift) an internal protocol was arranged and followed for measurement tests. As the drift measurements have been taken up to seven meters in height, eso and endo-drift indexes were generated showing the average value of the deposit found up to that height and at the respective sampling distance. Arose results showed that at first the most appropriate equipment to adopt in that growing contest appeared on-target sprayers with anti-drift air injector nozzles (Bondesan & Rizzi, 2010).
Due to the instability of wind conditions during treatments, as to ensure the maximum level of drift reduction, more tests were necessary to find other solutions adoptable together with the devices already tested. The first results of this recent comparative tests are presented and discussed in the following paragraphs.

Materials and methods
For that purpose different devices for the distribution of pesticides have been compared. The tested equipments were: a tower sprayer prepared with ATR swirl nozzles; the same sprayer equipped with anti-drift air injector nozzles (AVI) and a device for airflow exclusion by one side; a handheld gun sprayer model Nehro (Braglia) with manometer (Fig. 1).

Fig. 15. Equipments compared during the test: particular of the side flow exclusion device (right), the double crown of nozzles (left) activated indipendently and the handheld gun fitted with manometer (oval box).

The experimental activity took place in a Golden Delicious orchard, row distance of 3.4 m, hight of plants from about 2.0 m (fault replacements) up to 3.9 m.
Five rows were sprayed with a tracer solution of yellow tartrazine and Petri dishes were used to collect the ground deposit under the row and at different distances from the edge of the orchard up to 22 m. The tower sprayer equipped with the side airflow exclusion device was used to spray the row of edge and the adjacent one only from the outside to the inside part of the orchard, avoiding the use of air and liquid flow directed out of the orchard. The same equipment arranged in the standard configuration (reference) and the spray gun were used to spray as in a standard application thus treating each side of the row.
The main working parameters and adjustments used during the trials are resumed in Tab. 1.
The presence of a double crown which allowed to activate independently each series of nozzles and the comparison of the diagrams obtained by a calibration on patternator with both types of nozzles suggested to operate with the same nozzle configurations described in the calibration report.
The average speed of the operator treating with the handheld equipment was determined during the experimental application while the liquid flow rate was determined at the end of the application as the average of five measurements.

Tab. 1. Working parameters and adjustments used during tests.

Equipment	Type and number of nozzles	Pressure (bar)	Nozzle flow rate (l min^{-1})	Operative speed (km h^{-1})
Tower sprayer + ATR orange	Swirl cone 6+6	7	1.17	5.3
Tower sprayer + AVI yellow + side flow exclusion	Flat fan air injection 5+5	8	1.31	5.3
Handheld lance (gun) + orifice ø1.5 mm	Metering disk 1+1	28	6.42 (average)	0.9 (average)

The tests were conducted under conditions of moderate wind (average speed of around 1.0 m/s) and light vegetation (Fig. 2). Three replicates for each tested equipment were carried out.

Fig. 2. Picture of vegetation of the experimantal orchard (row of edge).

Results

The average values of the three replicates are shown in Fig. 2. These results are expressed as the percentage of the sprayed volume (normalised values).

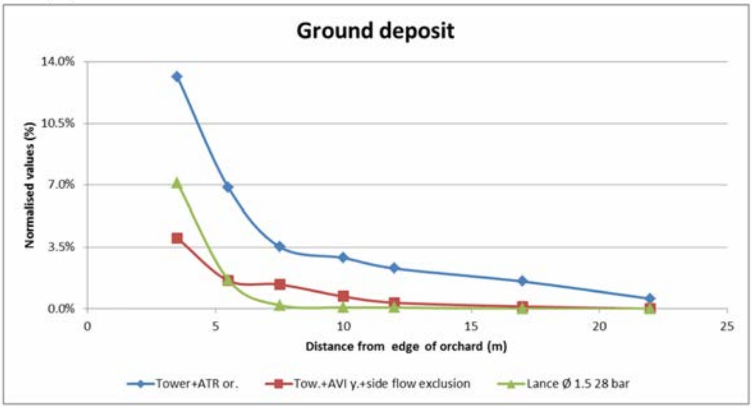

Fig. 3. Normalised values of ground deposit retrieved for each of the tested equipment (average values from three replicates).

Looking at the graphic is evident the mitigation ability on reducing the eso-drift both for the handheld gun and the tower sprayer with anti-drift devices in comparison with the reference equipment. The curve of the spray gun starts higher in the first meters above the row of edge and decrease more rapidly than the tower sprayer arranged in the anti-drift configuration (red curve). Moreover taking a look at the Tab. 2 it is possible to appreciate what happens in terms of increase/reduction when the ground deposit retrieved under the row and the eso-drift amount are refered to the real application volume. The difference between the very high application volume typical of the handheld equipments and the (adjusted) standard volume applied by the tower sprayer is mainly marked by the increase of ground losses under the trees.

Tab. 2. Comparison between drift reducing equipments and the reference sprayer equipped with swirl nozzles considering typical standard application volumes (tower sprayer 1,500 l/ha; handheld gun 2,500 l/ha)

Equipment	Tower ATR	Tower AVI + Side Flow Exclusion	Handheld lance
Eso-drift deposit	Reference	-76,4%	-67,8%
Under row deposit	Reference	-52,9%	+41,2%

Discussion

The factors that contribute to determine drift and its intensity are multiple and closely related one another. The behavior of the operator is essential for directing the success of treatment, finding the right balance to maximize the application efficiency and minimize losses.

This is easily accomplished with the adoption of technologies routinely used in the phytoiatric management of the orchard (air-carrier sprayers), as the operator can precisely adjust speed, pressure and spray application volume.

Equipping modern air-carrier sprayers with proper devices (tower conveyors, anti-drift nozzles, devices for airflow side exclusion or reduction, etc.) it seems to be possible to contain the dispersion of product much more than the handheld equipment.

Handheld sprayers – even if equipped with additional devices such as manometer – are not easily adjustable by the operator (Bjugstad & Skuterud, 2009). The performances of the handheld lance are spoiled by the high volume of application related to the impossibility of a precise calibration. This equipment proves to be more suitable as a tool for localized rescue applications or when mechanization is unrealizable, rather than as a real solution for reducing waste and drift.

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