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Standardized Procedure for the Inspection of Sprayers in Europe

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Advice for bush and tree crop sprayer adjustment



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This document has been compiled by the SPISE Technical Working Group 6.

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1 Introduction

In the Article 8 of the EU Directive 128/2009/EC it is foreseen that professional users have to be properly trained about the procedures for calibration/adjustment of sprayers, in order to be able to apply them with their own equipment in an appropriate and environmental safe way. Sprayer calibration made at farm in the field is however limited due to the lack of appropriate instruments/devices available, except for those that have been provided together with the machine, and that are described in the user manual. An **off field sprayer adjustment** can be therefore made from time to time by the authorized workshops as a complement to the sprayer inspection/calibration.

In practice, it is important to distinguish the difference between the sprayer calibration and the sprayer adjustment.

Sprayer **calibration** aims at achieving a determined spray volume application rate through the selection of the appropriate forward speed, operating pressure, nozzles types and sizes (nozzle flow rate). The basic data to make sprayer calibration are derived from the functional inspection. Calibration can also be made directly by the professional user, when he's adequately trained.

Sprayer **adjustment**, on the other hand, is focused to the adaptation of the sprayer output (both liquid and air) to the specific crop and eventually environmental situations present in the farm (Balsari *et al.*, 2007). To guide and verify the correct sprayer adjustment off field, it is necessary to use ad hoc test benches.

This document provides some advice on how to operate orchard/vineyard sprayers off field **adjustment** at the workshop and about the type of instruments needed with their minimum technical requirements.

2 Sprayer adjustment

It is an operation that shall be made at the end of the functional inspection, but before the calibration of the sprayer. It has to be carried out for each crop type and situation present in the farm or at least for the most representative ones.

Only a correct adjusted sprayer guarantees that:

- the spray mixture is addressed to the target;
- the use of PPP is optimized;
- the risks for the environment (e.g. spray drift) and for the consumers are minimized (Andersen & Jørgensen, 2009; Bondesan *et al.*, 2012).

The operative parameters of the sprayer to take into account for the sprayer adjustment made off field are the following:

1. Velocity and direction of the air stream generated by the sprayer fan;
2. Vertical distribution pattern.

In order to carry out an optimal adjustment of these sprayer parameters it is necessary to know:

- Type and layout of the bush or tree crop;
- Training system;
- Height and width (thickness) of the vegetation in the different seasons;
- Height of the target band if different from the total height of the plant;
- Target type sprayed (e.g. trunk, leaf or fruit).

Shall be underlined that the figures following reported are only examples, as the criteria for optimal adjustment may be different from region to region.

3 Air velocity

Fan air flow rate parameter does not provide enough information for the correct use of the sprayer, as equipment fitted with different nominal air flow rates for the fan, may produce similar air velocities at the target position. As widely reported in literature (Holownicki et al., 2002; Marucco et al., 2008), the air velocity considerably affects the quality of spray distribution as high velocities may increase drift (Triloff, 2012) and may orient the leaves parallel to the air flux resulting in lower spray deposits on their surfaces. Especially when applying espalier trained plants, the vertical profile of the air velocity should be even along the whole vegetation wall (Fig. 1).

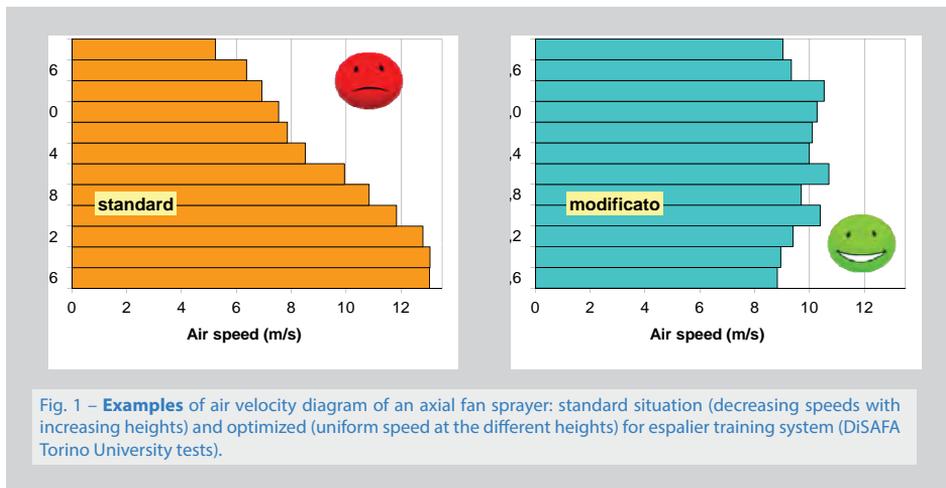


Fig. 1 – **Examples** of air velocity diagram of an axial fan sprayer: standard situation (decreasing speeds with increasing heights) and optimized (uniform speed at the different heights) for espalier training system (DiSAFA Torino University tests).

In order to measure the air velocity at different heights of the target canopy it is necessary to use an anemometer (manual measurement, Fig. 2A) or a specific test bench (Fig. 2B) having **at least** the following **technical features**.

A - Manual measurement:

- anemometer minimum measuring range: 0÷25 m/s
- horizontal measurements distance: min 1.0 m
- vertical measurements distance: up to tree top
- horizontal spacing between measurements: max. 100 mm
- vertical spacing between measurements: max. 250 mm
- number of measurements per position: 1

B - Test bench:

- number of anemometers: 1
- anemometer measuring range: 0÷25 m/s
- horizontal translation step: min 1.0 m
- vertical translation: up to tree top
- horizontal spacing between measurements: max. 100 mm
- vertical spacing between measurements: max. 250 mm
- number of measurements per position: 1



Fig. 2 **Examples** of sonic anemometer (A) and test bench with sonic anemometers (B) allows to obtain the vertical profile of air flow and air velocity. This information can be used to adjust the sprayer according the intended canopy target. (Photo G. Oggero, DiSAFA Torino University).

To modify the air velocity it is possible to operate on:

1. tractor gear and RPM (not advisable because it may conflict with the rule to check for pump performance at nominal PTO speed);
2. fan rotation speed, if a fan gear-box is present, and inclination of the fan blades of axial fans (Fig. 3);
3. air outlet section (Fig. 4);
4. air inlet section (Fig. 5 and Fig. 6).

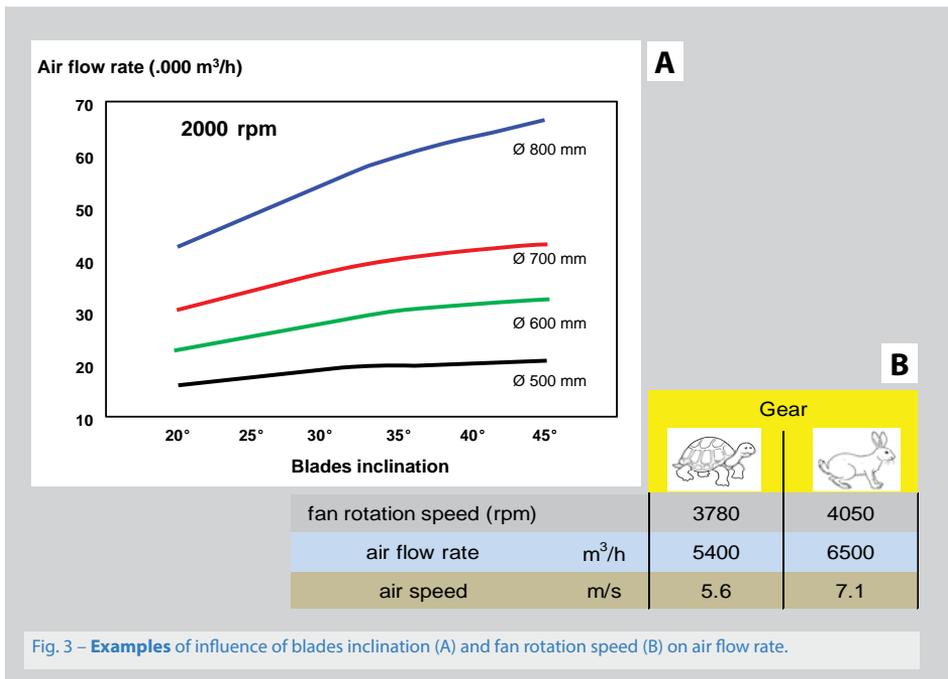
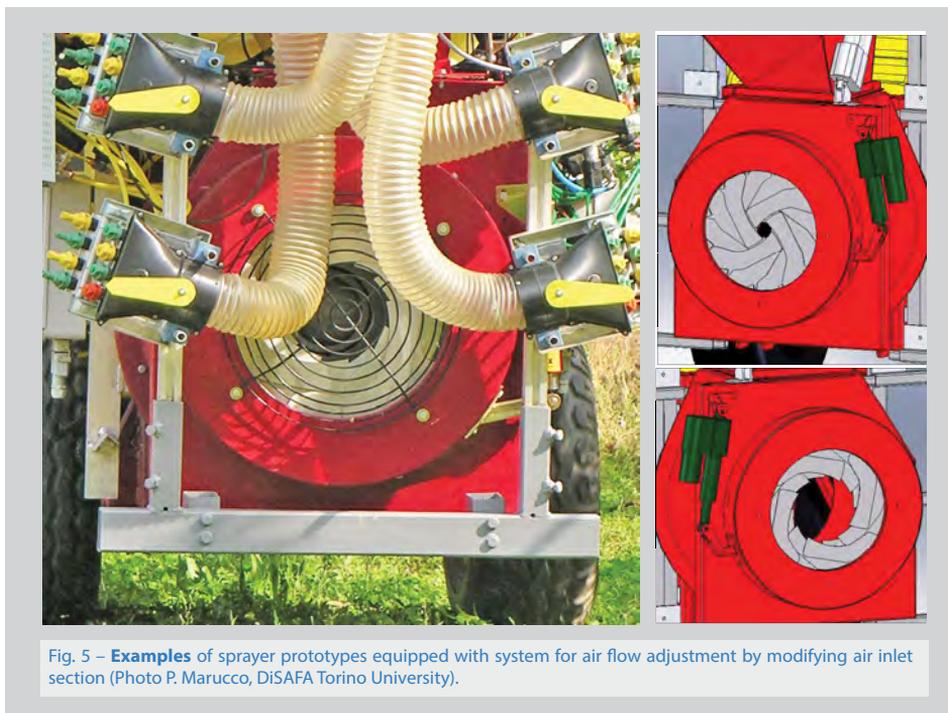


Fig. 3 – **Examples** of influence of blades inclination (A) and fan rotation speed (B) on air flow rate.



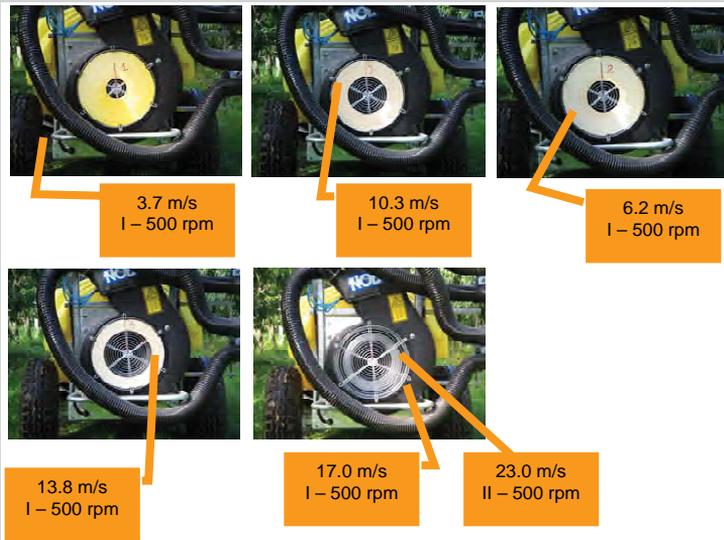
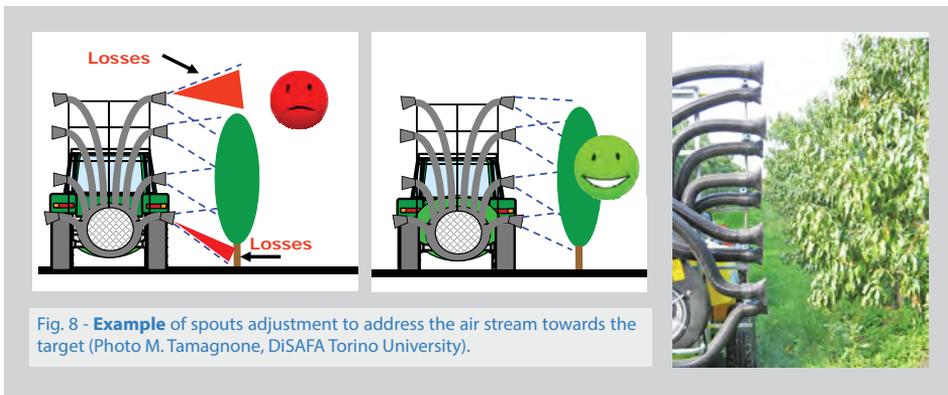
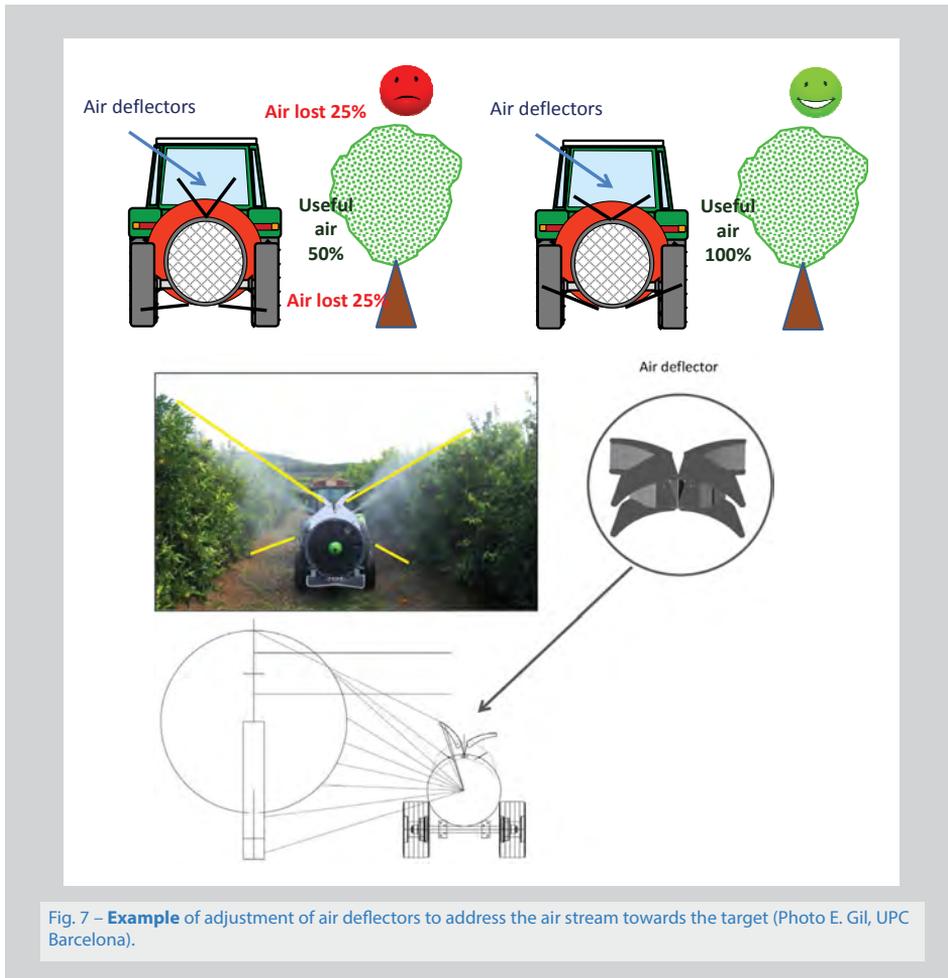


Fig. 6 - **Example** of a simple way to modify fan air inlet surface and consequently air speed (Photo M. Tamagnone, DiSAFA Torino University).

To modify the air direction it is possible to operate on:

1. inclination of the air deflectors (Fig. 7);
2. dimension and orientation of spouts (pneumatic sprayers and multi spouts sprayers) (Fig. 8).



4 Vertical distribution pattern

4.1 Determination of vertical distribution

This operation is performed to verify if the emitted spray plume matches with the target crop shape and dimensions.

In this phase, it is necessary to refer to the plant height reached at the fully development growth stage: one of the scopes of this operation consists in adjusting spray profile to avoid to blow droplets over the top of the trees and consequently to minimize the negative environmental impact (less drift) and to save PPP.

Moreover, it is important that the spray volumes applied are adapted according to the variations of the canopy surface/area typical for the applied crop.

In most of the training systems, differences in the vegetation surface/area can be observed at the different heights, with larger differences especially when vegetation is fully developed. Therefore, to guarantee an uniform spray coverage it is necessary to take into account these variations in the canopy, with more spray addressed to the denser areas and less spray applied in the area with poor vegetation.

As an example, especially for orchard training systems, it is possible to say that a good vertical spray profile is based on the knowledge of where the densest part of the canopy is present (Fig. 9).

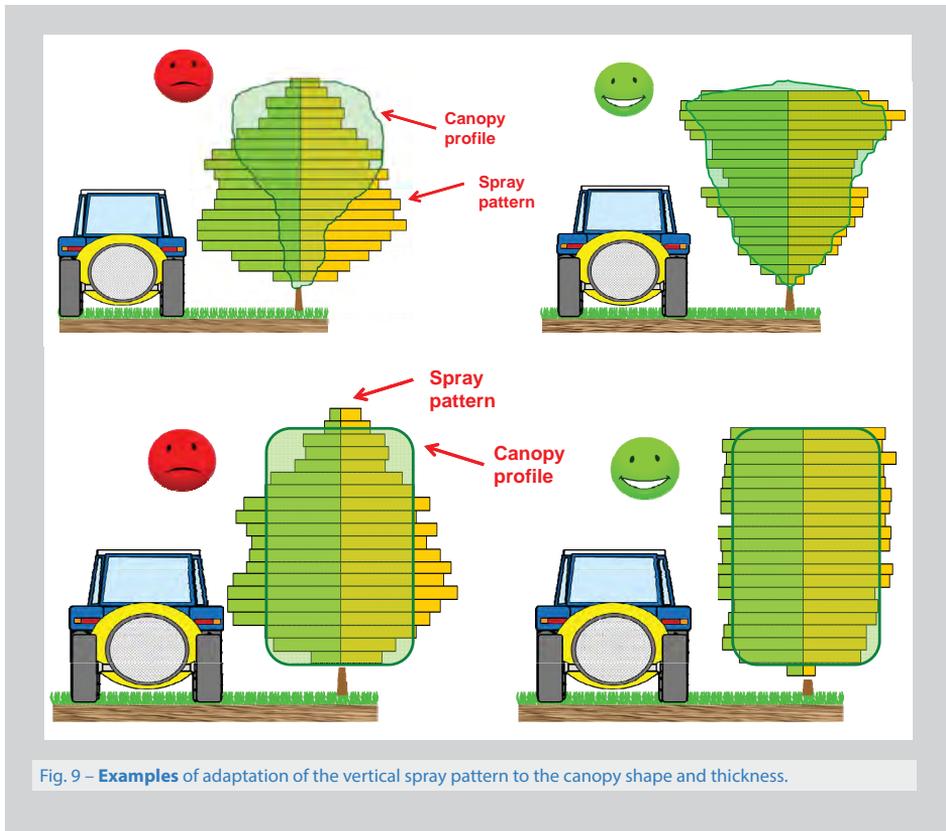


Fig. 9 – Examples of adaptation of the vertical spray pattern to the canopy shape and thickness.

Nozzles shall be therefore selected and oriented with the aim to achieve a spray pattern, having its maximum in correspondence of the highest density of the canopy. When it is intended to apply plants trained at espalier systems, a uniform vertical distribution is needed in order to achieve an even spray coverage within the whole vegetation wall.

To determine the vertical spray pattern of a sprayer for tree-based crops a specific vertical test bench shall be used, having continuous or discrete elements (Fig. 10). Several studies made in the past (Pergher *et al.*, 2002, Allochis *et al.*, 2015) demonstrated that using these types of test benches it is possible to obtain a good estimation of the spray recovery on the target.

In case of multiple row sprayers it is also possible to use a specific test bench (Fig. 11).



Fig. 10 – **Examples** of vertical test benches provided with discrete or continuous elements (Photo G. Oggero, DiSAFA Torino University).

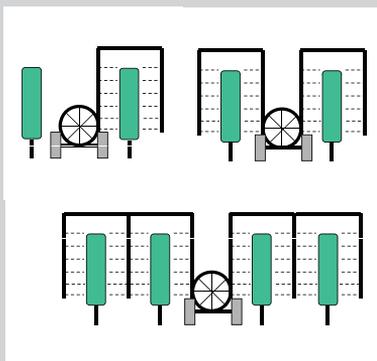


Fig. 11 - **Example** of vertical test bench provided with discrete elements for multi row sprayers (Photo D. Allochis, DiSAFA Torino University)



Minimal technical characteristics of these spray caption walls shall be:

- Size of each single collector (in case of test benches having discrete elements) $\geq 180 \times 220$ mm;
- It shall be possible to collect the sprayed liquid along the whole height of the spray plume without any interruption. Vertical distance between two adjacent collectors shall be ≤ 300 mm;
- Liquid from the test bench shall be collected in graduated cylinders which shall have a capacity ≥ 50 ml and content scale $\leq 1\%$ of their capacity.

If targeted plants are trained with systems overcoming the sprayer (e.g. “Tendone” and “Pergola”, Fig. 12 and Fig. 13) it shall be necessary to use specific test benches (Pascuzzi, 2013) enabling to collect the liquid sprayed above the machine (Fig. 14).



Fig. 12 – **Examples** of “Tendone” (photo: www.agricardclub.com) and “Pergola” (photo: www.dorigati.it) trained systems.



Fig. 13 – **Examples** of sprayers used for spray distribution in “Tendone” vineyard (Photo S. Pascuzzi, DiSAAT Bari University).



Fig. 14 – Example of test bench for sprayers used in “Tendone” trained vineyards or similar trained crops (Photo D. Civitella, ARSSA Abruzzo and S. Pascuzzi, DiSAAT Bari University).

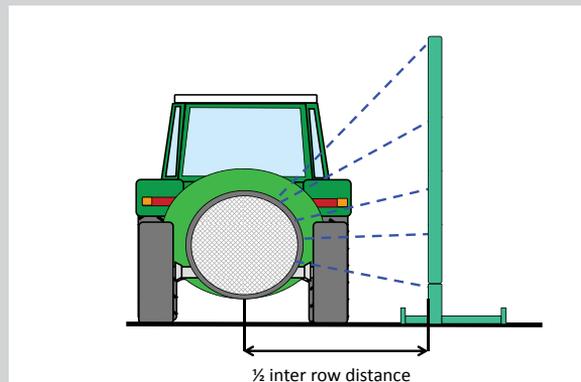


Fig. 15 – Positioning of the test bench with respect to the sprayer.

The test shall be carried out positioning the test bench at a distance from the center of the sprayer equals to half the inter-row distance (Fig. 15).

When self-moving test benches are employed (able to move autonomously along a rail), the test is made with the sprayer in static position (the vertical test bench moves at certain forward speed up and down the rail). At the beginning of the test, the vertical test bench must be positioned at one edge of the rail track.

Then, it is necessary to activate the sprayer and to collect an amount of liquid on the test bench sufficient to determine the liquid distribution diagram (the graduated tube where the highest amount of liquid is collected shall be filled at least at 70% of its capacity). If during the test the level of liquid collected in at least one of the tubes exceeds the maximum value of the graduated scale, then the test shall be repeated.

Once the acquisition of data is completed, the test shall be repeated on the other spray side of the sprayer. Attention shall be paid in order to make for both sprayer sides the same/similar number of passes with the test bench in front of the spray plume.

4.2 Results evaluation

If the result obtained is not the required one, i.e. if the vertical spray pattern is not compatible with the vegetation profile or there are differences between the two sprayer sides, it is necessary to modify the number of active nozzles, their position and/or orientation (when possible) and their flow rate. There are no specific and precise rules about this aspect. The choice of nozzle size (and spray pressure) shall be always related to the vegetation conditions of the target. For example, when canopies featured by a large amount of vegetation in their top part - in the case of the use a conventional air blast sprayer - the nozzles that spray towards the top of the plants shall be larger in order to provide adequate spray coverage on this part of the trees (Fig. 16). On the other hand, for espalier trained plants, it is necessary to provide a more homogeneous vertical spray diagram along the canopy height, therefore it will be recommendable to use nozzles of the same size along the spray line of each sprayer side.

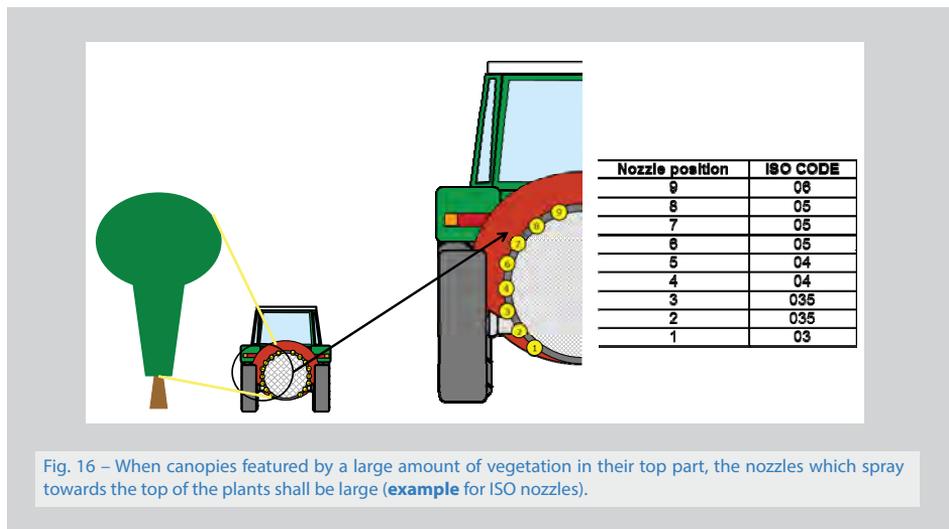


Fig. 16 – When canopies featured by a large amount of vegetation in their top part, the nozzles which spray towards the top of the plants shall be large (example for ISO nozzles).

To modify the vertical spray pattern, it may also be needed to adjust the direction and the intensity (air speed and volume) of the air stream generated by the sprayer fan (see chapter 4). Axial fans, generally mounted on air-assisted sprayers, are featured by an air stream that is not symmetric on the two sides of the machine. This inconvenience may be, at least partially, solved by closing the top nozzle on one side of the sprayer and the bottom one on the other side or changing in the sprayer side the nozzles orientation (Fig. 17).

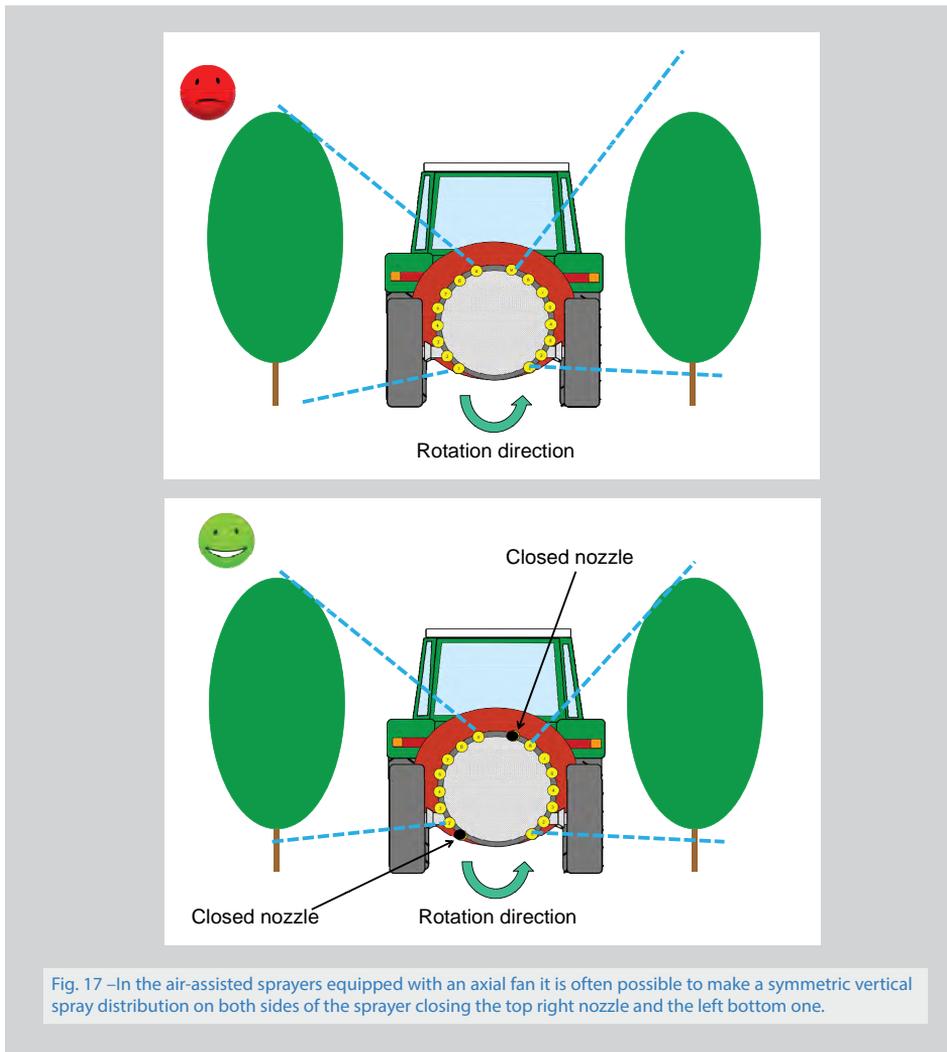


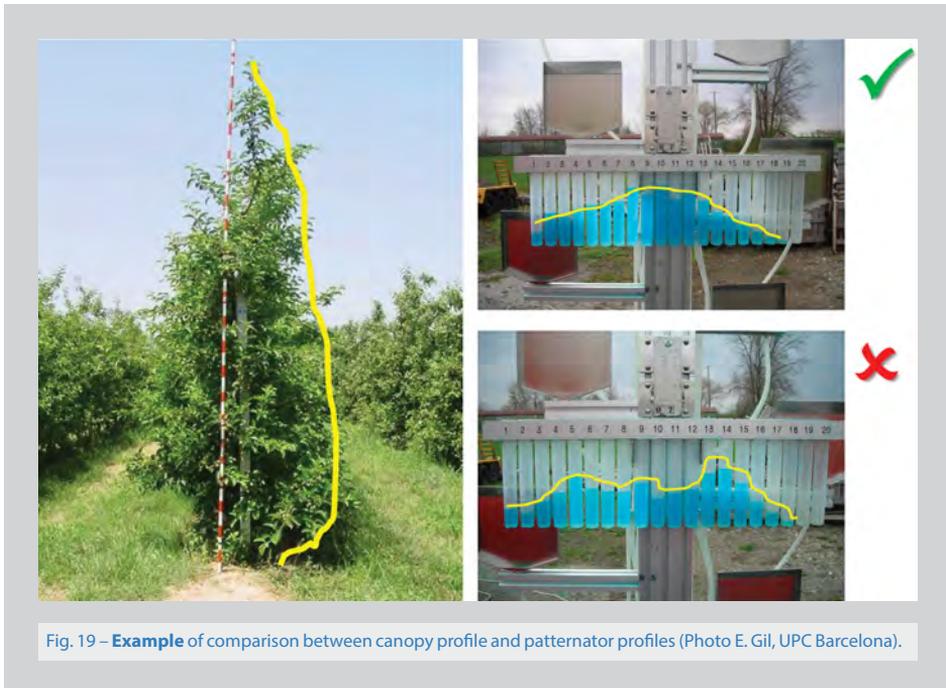
Fig. 17 –In the air-assisted sprayers equipped with an axial fan it is often possible to make a symmetric vertical spray distribution on both sides of the sprayer closing the top right nozzle and the left bottom one.

Concerning pneumatic sprayers, the adjustment of the width of the spray plume can be made through different systems (regulation valves to close partly the spouts, different positioning and orientation of the spouts along their supports on the sprayer, etc.). When multi spouts elements are available, it is also possible to select the number of active spouts or modify the size of their outlet in order to vary the spray pattern profile (Fig. 18).



Fig. 18 – **Example** of vertical distribution pattern evaluation using a sprayer with individual outputs (Photo E. Gil, UPC Barcelona).

Results obtained after vertical patternator test shall be compared with canopy profile. The two profiles (outside of the canopy and patternator - Pergher et al., 2004, Gil et al., 2007 and 2013) shall be similar as possible (Fig. 19).



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SPISE – Standardized Procedure for the Inspection of Sprayers in Europe

Established in 2004 by founding members from Belgium, France, Germany, Italy and the Netherlands, the SPISE Working Group aims to further the harmonisation and mutual acceptance of equipment inspections. In regular meetings, several Technical Working Groups (TWG) prepare advice about the items taken into account by the EU Directive 128/2009/EC but still not considered in the actual ISO/CEN Standards. The present document is intended to provide technical instructions and describes a procedure which is not mandatory but can be voluntary adopted in the course of inspection or calibration.

Further information can be found at <http://spise.jki.bund.de>

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