# Best Management Practices
## to reduce spray drift

TOPPS PROWADIS

**Authors:**
Technical Support team: spray drift
Paolo Balsari, Paolo Marucco (Univ. Turin, Turin, IT),
Greg Doruchowski (InHort, Skierniewice, PL),
Holger Ophoff (Monsanto),
Manfred Roettele (BetterDecisions, Dülmen, DE)

**Local spray drift partners:**
Sébastien Codis (IFV, Grau du Roi, FR),
Emilio Gil (Univ. Polytech. Catalunya, Barcelona, ES),
Poul Henning Petersen (Danish Agriculture Advisory Service, Aarhus, DK),
Andreas Herbst, (Julis Kühn-Institut, Braunschweig, DE),
Ellen Pauwelyn (InAgro, Rumbeke, BE),
Tom Robinson (Syngenta),
Klaus Sturm (Bayer CropScience)

This document was developed within the TOPPS Prowadis Project and sponsored by ECPA (European Crop Protection Association), Brussels, BE



**Pictures:**
Originate from our TOPPS prowadis partners USDA

Dipartimento di Economica e Ingeneria Agraria Forestale e Ambientale (DEIAFA),
Università di Torino –Via Leonardo da Vinci 44,
Grugliasco (TO), Italy

Institut Français de la Vigne et du Vin,
Domaine de l'Espiguette
F - 30240 LE GRAU DU ROI, France

Inagro vzw
Ieperseweg 87
8800 Rumbeke-Beitem, Belgium

Research Institute of Horticulture
Konstytucji 3 Maja 1/3,
96-100 Skierniewice, Poland

Julius Kühn-Institut (JKI)
Bundesforschungsinstitut für Kulturpflanzen
Messeweg 11–12, 38104 Braunschweig, Germany

Knowledge Centre for Agriculture
Agro Food Park 15
8200 Aarhus N, Denmark

Universitat Politécnica de Catalunya,
C/ Jordi Girona, 31,
08034 Barcelona, Spain

**TOPPS** projects started in 2005 with the 3-year funded project from Life and ECPA to reduce losses of Plant Protection Products (PPP) to water from point sources. TOPPS eos (2010) evaluated technologies on their contribution to optimize the environmental friendliness of sprayers.
The follow-up project TOPPS Prowadis (2011 to 2014) is focused on the reduction of diffuse sources. TOPPS Prowadis is funded by ECPA, involves 14 partners and is executed in 7 EU countries.

**TOPPS** projects develop and recommend Best Management Practices (BMP) with European experts and stakeholders. Intensive dissemination through information, training and demonstration is conducted in European countries to create awareness and help to implement better water protection.
TOPPS stands for: Train Operators to Promote Practices & Sustainability (www.TOPPS-life.org)

# Contents

## FOREWORD

Protecting water is high on the list of public concerns about the environment, and it is recognized as one of the basic elements required for all life on the planet.

ECPA sees protection of water as a key pillar of its work and is strongly aware of the need to work continuously to support correct use of pesticides as part of sustainable and productive agriculture. We therefore set ourselves the task of working together with our own national associations and a broad group of international partners to develop and disseminate appropriate measures, recommendations and training materials to ensure that all relevant aspects of water protection are addressed, and that broad consensus is achieved on the recommended measures (referred to as Best Management Practices – BMP).

This collaborative effort to build and improve available tools for water protection also fits very closely with the objectives contained in relevant EU legislation such as the Water Framework Directive (WFD) and the Sustainable use of Pesticides Directive (SUD). Our work has resulted in the multi-stakeholder TOPPS projects which have been launched since 2005 in many EU countries, supported by ECPA and for the first three years also by the EU Commission (Life).

The TOPPS projects initially focused on the mitigation of point sources such as may occur when cleaning or emptying sprayers or as a result of spills, and now from 2011 we are seeking to concentrate on the more complex mitigation of diffuse sources entries (primarily run-off and drift) so as to offer a broad set of recommended BMP to protect water. We refer to this new phase of the TOPPS projects as TOPPS Prowadis. It is our hope that these resulting BMP will be used as a basis to inform, educate, and train operators, advisers and stakeholders in a range of different ways – in the classroom, in the field, and through demonstration. ECPA is committed to promote the implementation of these BMP.

I would like to sincerely thank all the partners and experts for their great efforts and contributions to the TOPPS projects, both in terms of the technical know-how they have brought to the table, and their willingness to work together to achieve consensus on our common goals. I also truly hope that these BMP will help spark the enthusiasm that will be needed to implement these ideas "on the ground" and help create awareness and spread the knowledge which is necessary for sustainable use of pesticides and a high level of water protection.

**Friedhelm Schmider**

Director General
European Crop Protection Association
Brussels, Belgium

European Crop Protection

## INTRODUCTION

According to the definition given in the ISO 22866 Standard "spray drift is the quantity of plant protection product that is carried out of the sprayed (treated) area by the action of air currents during the application process". The consequence of the dispersion of part of the spray mixture out of the applied field may include the contamination of water courses, sensitive areas (e.g. natural parks, children's playgrounds, wetlands, etc.), urban areas or the unintended spray deposition on adjacent crops. This latter may result in residues of not allowed active ingredients or direct damage (phytotoxicity) on adjacent crops (Fig. 1)

Fig. 1: Example of spray drift generated during spray application in vineyard.

The recent European Directive 128/2009/EC on the sustainable use of pesticides gives specific indications for preventing environmental risks related to spray drift. In particular, Article 11 of this Directive, which is entitled "Specific measures to protect the aquatic environment and drinking water", foresees the necessity:

a) To prevent drift by "giving preference to the most efficient application techniques such as the use of low-drift pesticide application equipment especially in vertical crops such as hops, and those found in orchards and vineyards"

b) To reduce drift risk exposure by "use of mitigation measures which minimise the risk of off-site pollution caused by spray drift, drain-flow and run-off. These shall include the establishment of appropriately-sized buffer zones for the protection of non-target aquatic organisms and safeguard zones for surface and groundwater used for the abstraction of drinking water, where pesticides must not be used or stored"

**MITIGATION MEASURES**
**to reduce spray drift can be classified in direct and indirect measures (Fig. 2).**

1) Direct measures, aimed to reduce spray drift at the source (formation and direction of the spray droplets). These measures are mainly addressed through application technologies, sprayer accessories designed to decrease spray drift generation and correct sprayer adjustment.

2) Indirect measures, aimed to reduce spray drift by measures to "capture spray drift" like buffer zones, no spray zones or barriers (e.g. windbreaks, hail nets, etc.).

It is very important that the operator respects the recommendations regarding optimal weather and environmental conditions for spraying.

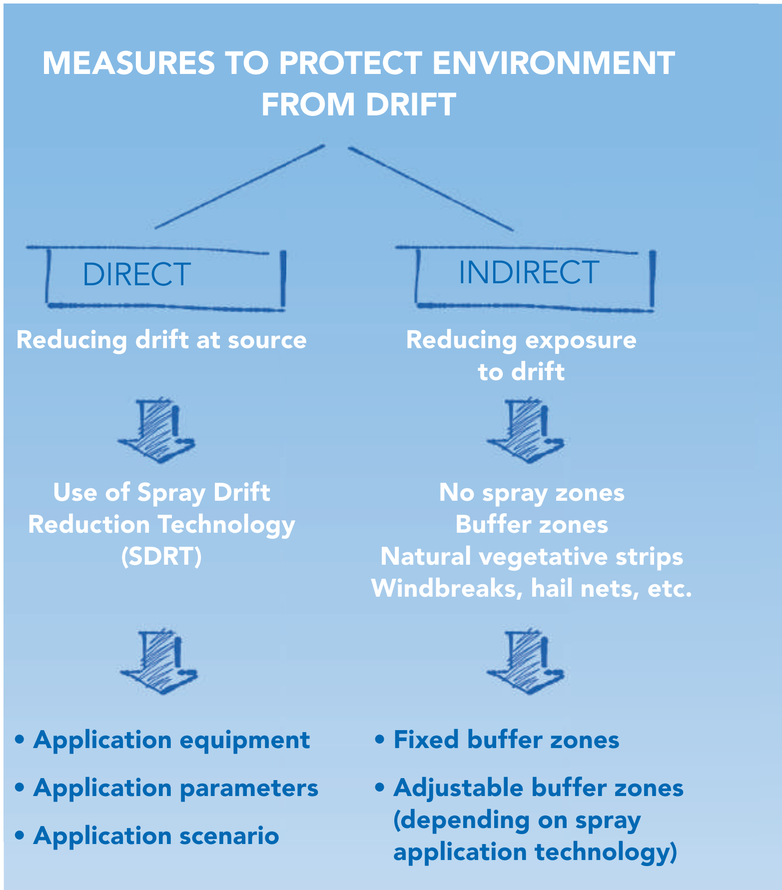



Fig.2: Measures to protect the environment from spray drift.

## DEVELOPMENT OF THE BEST MANAGEMENT PRACTICES MEASURES (BMP)

### Low level of harmonization today

After an inventory process, where the local situation was reviewed by the TOPPS Prowadis partners in their countries it became obvious that the level of harmonized recommendations across the EU is low. In some countries Spray Drift-Reducing Techniques (SDRT) are tested and categorized by their ability to reduce the spray drift. Currently, SDRT technology is mainly focused on measures to reduce the amount of fine droplets mainly by modifications of hydraulic nozzles predominantly used in field applications. In some EU countries implementation of SDRT has been largely accepted for field applications, in others the implementation until now is low.

The testing and categorization of vine and orchard sprayers is more complex and to date only few countries have started to recommend and categorize spray drift-reducing sprayers and technology. Higher complexity in orchard and vine applications needs to concentrate on the whole sprayer configuration and technology and not mainly on the aspect of spray formation, as for field application. It should also be noted that especially in the Southern EU countries many farmers use sprayers with pneumatic atomisers, which have little flexibility to modify the droplet spectrum.

### EU core Best Management Practice reference

Due to the diversity of the situations across the EU countries Best Management Practices (BMP) need to be adapted to the specific local conditions. It is intended to address these specific issues in the local information and training materials, which will be prepared on the basis of this reference booklet. With this document we intend to propose an EU core for BMP, which could serve as a platform for more harmonization and development.

Why more harmonization is an advantage:
It is important to have a harmonized framework of recommendations, to create a common baseline for operations among countries, to develop the trust levels necessary for their implementation. Trust is essential, as immediate benefits of a changed practice or investment in new technology is not always obvious, and longterm benefits are not always sufficiently valued.

## BMP consultation process

The project team for drift made a first proposal for BMP, which was discussed at national forums with national stakeholders. After this first consultation in all the TOPPS Prowadis countries, through the TOPPS partners, an EU stakeholder workshop was organized in Brussels (26 April 2012) to discuss and consolidate the draft versions for the final BMP document.

## Structure of BMP measures

BMP were developed in a two-step approach

**a** **Statements =**
**What to do (brief sentence)**

**b** **Specifications =**
**How to do it (short explanation of possible ways to achieve the result)**

The statements are considered to represent "the European core", which should be followed by all member states (framework). These statements were the main focus in the consultation process.

Specifications should give guidance on how to do things in a correct way. In an EU reference document such specifications cannot address specific recommendations in individual countries. Any specific aspects are included in the national TOPPS Prowadis information and training materials.
Proposed BMP do not interfere with the label requirements or other legal obligations of the Plant Protection Products (PPP). These need to be respected by all means. BMP intend to provide practical and consistent guidance to operators, sprayer manufacturers and other stakeholders in order to make the use of PPP more sustainable.

TOPPS Prowadis spray drift BMP have been divided into three main sections:

1. **General measures to reduce spray drift (valid for field crop or for orchard sprayers)**

2. **Measures to reduce drift from field crop sprayers**

3. **Measures to reduce drift from fruit crop sprayers**

In the course of the consultation process stakeholders requested that the BMP are proposed in a certain order of importance to follow. This is achieved by colour coding of the recommendations:

**1 Green: must be implemented**

**2 Yellow: very important to follow**

**3 Blue: important, specifications to be adapted to local conditions**

The BMP are grouped by CATEGORY in order to help the reader to easily find the BMP.

Six different categories have been selected:

- Environmental factors
- Weather conditions
- Spray generation
- Spraying equipment
- Sprayer adjustment
- Sprayer operation

## Precondition: APPLICATION SITE

| Distance between the sensitive area and the spray application site |
|---|
| Spraying **within** the zone of awareness (buffer zone + boom width) |
| Spraying **beyond** the zone of awareness ((buffer zone + boom width or 20 m) |

## Situation: METEO & FIELD CONDITIONS

**WIND**

| Wind direction |
|---|
| NO WIND |
| **TOWARDS sensitive area** |
| PARALLEL to sensitive area |
| AWAY FROM sensitive area |

| Wind velocity |
|---|
| CALM <0,5 m/s |
| LOW 0,5–1,5 m/s |
| MEDIUM 1,6–3,0 m/s |
| **HIGH 3,1–4,0 m/s** |
| VERY HIGH >4,0 m/s |

**AIR**

| Air temperature |
|---|
| <15 °C |
| **15–25 °C** |
| 15–25 °C |

| Air humidity |
|---|
| <40% |
| **40–60%** |
| >60% |

**FIELD**

| Crop height |
|---|
| BARE SOIL |
| EMERGING CROP |
| **LOW <10 cm** |
| MEDIUM 10–50 cm |
| HIGH >50 cm |

| Adjacent vegetation |
|---|
| **BARE GROUND** |
| MEADOW |
| HIGH VEGETATION, WINDBREAK |
| HIGH >50 cm |

## MITIGATION: SPRAYING EQUIPMENT + ADJUSTMENT OF SPRAYER

| SDRT – drift reduction % |
|---|
| **NO SDRT** |
| 25% |
| 50% |
| 75% |
| 90% |
| 95% |
| 99% |
| OTHER |

| Boom height |
|---|
| <40 cm |
| **40–50 cm** |
| 51–60 cm |
| 61–80 cm |
| 81–100 cm |
| >100 cm |

| Driving velocity |
|---|
| 3–5 km/h |
| **5,1–7 km/h** |
| 7,1–10 km/h |
| 10,1–15 km/h |
| >15 km/h |

Fig. 3: Example spray drift evaluation tool; variables and parameters to be selected for field applications.

## SPRAY DRIFT RISK EVALUATION

**Before any application is made, it is recommended to make a spray drift risk evaluation of the fields/orchards to be sprayed.**

### Interactive spray drift risk evaluation tools for field, orchard and vine applications

The tools allow the operator to evaluate the drift risk, taking certain parameters and mitigation measures into consideration. The tools are based on practical and scientific experience and serve as a practical help to operators and advisers, increasing their awareness and understanding of spray drift, including possible mitigation solutions (example Fig. 3). The evaluation tools can be found on the TOPPS website (www.TOPPS-life.org or directly www.TOPPS-drift.org).

**First step**

In the first step of the evaluation, the distance of field borders to sensitive areas need to be characterized. This distance is called the “zone of awareness” and highlights if drift can be a problem (see Fig. 4).

The “zone of awareness” is the buffer zone distance requirement given in the label of the PPP intended to be applied, plus for:

**a|** Field application: the distance corresponding to a boom working width, or at least 20 metres

**b|** Orchard/vine applications: the distance corresponding to 5 rows, or at least 20 metres

It is assumed that the application of mitigation measures to reduce spray drift in the “zones of awareness” largely reduces spray drift.

**Second step**

In the second step parameters of the key variables influencing spray drift need to be selected. These are wind direction and velocity, air temperature and humidity as well as the application conditions related to the vegetation in the field and the type of vegetation next to the field (Fig. 3). In orchards and vine applications canopy density has to be considered (sprayer type/nozzles, spray and airflow scenarios belong to Third step)

**Third step**

In a third step, available mitigation measures can be selected to evaluate the drift reduction which can be achieved compared to a standard sprayer configuration. More details can be found by downloading the evaluation tool documentation from the TOPPS website (www.TOPPS-life.org).

Example of mitigation measures for field crop application:

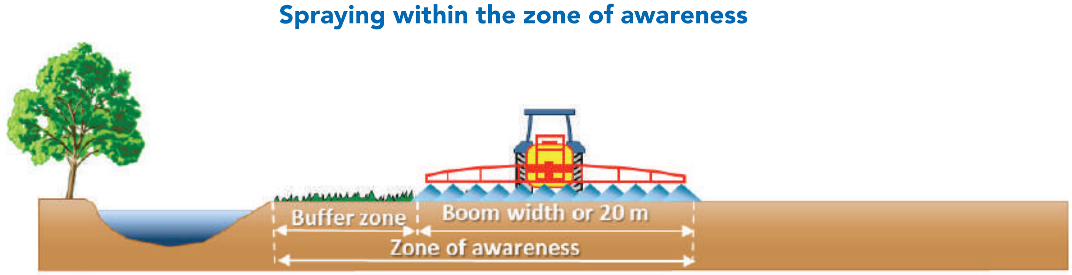
Drift-reducing nozzles (SDRT), height of the spray boom and the driving speed of the sprayer. The drift risk will either increase or decrease, depending on the selection of the mitigation options. This is displayed in a per cent scale, where the configuration of the selected sprayer is compared to a standard.

Standard sprayer configuration for field applications:

Flat fan nozzles 110 degrees, size 03 operated at 3 bar pressure, or comparable in terms of droplet size
Spray boom height 50 cm
Sprayer speed 6-8 km/h (to be consistent with DET)

The offline and online tools are available for field crop, vineyard and orchard sprayers. They provide useful information n to make the operator aware of the spray drift risks, and also offer advice on possible solutions to reduce spray drift, before and during spraying.

a




b

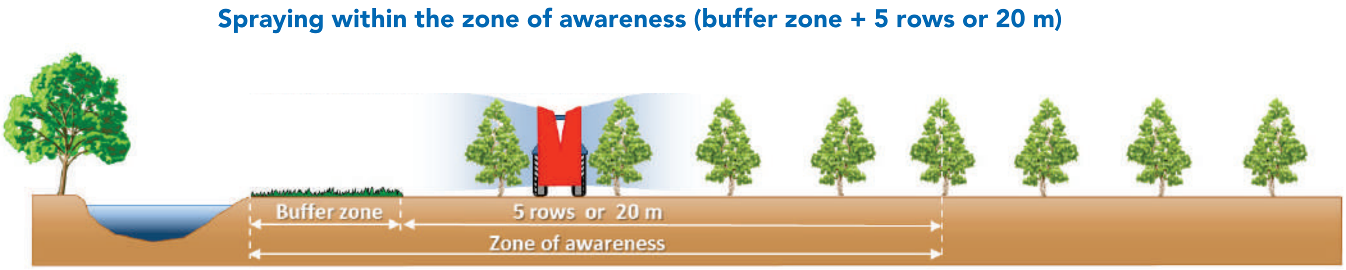



Fig. 4: Definition of the "zone of awareness" in field and orchard applications.

## BEST MANAGEMENT PRACTICES MEASURES – GENERAL MEASURES FOR FIELD AND FRUIT CROPS

### Environmental factors

Before starting an application, environmental factors relevant for a spray drift risk should be considered. Most important is to know the **distance from a crop to be sprayed to any sensitive area**. Maps should be available where such information is documented and where **indirect mitigation** measures like buffer strips (e.g. hedges, windbreaks, other structures able to capture spray drift) are shown. Other major factors especially in orchards and vineyards are:

1) The canopy structure of the crop (height of field crops, planting, pruning and training system of orchards and vineyards, canopy density, phenology stage)

2) The evenness of canopy wall along the row (absence of space between adjacent plants)

3) Growth stage/status of the crop, which largely determines the spray drift risk especially in the rows closer to sensitive areas. Key consideration is the leaf density and leaf area able to capture the spray and keep it in the target area.

Environmental factors do not rapidly change and are therefore essential for any application plan and spray drift reduction strategy.

| BMP No. | Category | What to do | |
|---|---|---|---|
| 1 | Environmental factor | Use spray drift reduction measures, when spraying targets with low catch efficiency for the spray (reduced leaf area, crop stage) | |
| 2 | Environmental factor | Cap wells<br>Construct new wells correctly | |
| 3 | Environmental factor | Check local regulations and PPP label requirements concerning buffer zones | |
| 4 | Environmental factor | Keep existing vegetation or establish windbreaks/ retention structures between sensitive areas and fields being sprayed | |

## How to do it: specification

- Focus on critical situations, for example: pre-emergence herbicides sprayed on bare soil, dormant perennial crops, early growth stages in arboreal crops where leaf area is still too low to effectively capture the spray
- Identify position of missing plants in rows so that you can react to switch off sprayer at this position
- Use technical mitigation measures to reduce spray drift risk: e.g. adjust the sprayer for each application, use drift-reducing nozzles, reduce spray distance to target, etc.

---

- Follow national regulations, and/or construct new wells away from potential flooding areas and securely capped
- Document location of wells in your field maps
- Follow local regulations and mark distance requirements around wells
- Make sure that wells are securely capped and protected (wells are often directly connected with groundwater)

---

- Check PPP labels which indicate the distance regulations for buffer zones, which are part of the registration for all PPP
- Check if there are local requirements, which impose further distance regulations
- Buffer zone requirements for PPP can be modified in combination with spray drift-reducing technologies/installations (check national/local conditions)

---

- Preserve and maintain existing vegetation/windbreaks
- Establish buffer vegetation if your specific situation requires this. Depending on the crops the establishment requires different vegetation. Main aspects: height of "catch structure" – for orchards: 6 to 8 m, for field crops: 2 to 3.5 m; Density of canopy – conifers' permanent density or leafy structure which then need to develop earlier than the crop. Local expertise should be consulted for technical legal and funding advice before establishing a vegetative buffer
- Establish artificial spray retention structures (e.g plastic nets). Consult local expertise

---

1 Must be implemented 2 Very important to follow 3 Important, specifications to be adapted to local conditions

## Weather conditions

Weather conditions are the main influencing factors for spray drift. These conditions cannot be directly influenced and predicted. Wind speed, wind direction, air humidity and temperature are the key factors which need consideration. In most countries critical values are recommended, indicating the limits to be respected for spraying. If one of the key variables exceeds the limit it is recommended not to spray. These limits vary between countries and should always be considered and respected.

Wind speed influences the amount of fine droplets, transported away from the target area. The wind direction determines the direction of the spray "cloud" and if it drifts towards a sensitive area.

In situations where air humidity is low, water from the spray droplets is evaporated. This effect increases the amount of fine droplets and therefore increases the risk of unwanted transfer. If air temperature is too high, thermal effects tend to lift up small droplets and delay the sedimentation of the spray (thermal drift). Therefore the spray cloud is longer exposed to the transfer through wind.

| BMP No. | Category | What to do | |
|---|---|---|---|
| 5 | Weather conditions | Check the weather forecast when planning the spray activities | |
| 6 | Weather conditions | Check the weather conditions before actually starting the PPP application | |
| 7 | Weather conditions | Do not spray when wind speed exceeds locally recommended values or follow general orientation given in the specification | |
| 8 | Weather conditions | Spray in stable atmospheric conditions | |

## How to do it: specification

Use the local services to check the weather forecast for your area.

- Pay particular attention to wind direction and velocity as well as to air temperature and humidity for different times of day
- Plan spraying for the time with the most favourable weather conditions possible: low wind (below 2.5 m/s), moderate temperature (10–25 °C), and high air humidity (above 50%), forecasted wind direction away from sensitive zones
- Try to spray fields adjacent to sensitive zones when wind is most calm (morning/evening)

---

- Check the following weather parameters before starting to spray: wind direction, wind velocity, air temperature, air humidity
- Decide on starting the application, based on your judgement of the weather conditions; if available make actual measurements (own weather station or mobile devices)
- Make sure that the sprayer is equipped and adjusted correctly to mitigate the drift risk as much as possible

---

- If no legal requirements about wind velocity are specified, preferably spray at LOW and MEDIUM wind (0,5 - 3,0 m/s), at spray dispersion height
- In case of HIGH wind (3.1–5.0 m/s) stop spraying until the wind speed decreases
- If timing is a critical factor or for other reasons the PPP application cannot be postponed use the most efficient drift mitigation measures available
- Never spray at VERY HIGH wind speed (>5.0 m/s)

---

- Avoid spraying during hot, calm summer evenings to avoid thermal drift
- Spray at the cooler time of day if possible (morning)
- If timing is a critical factor or the PPP application cannot be postponed use the coarse or very coarse spray nozzles, reduce air-flow and travel velocity (use mitigation measures)

---

1 Must be implemented   2 Very important to follow   3 Important, specifications to be adapted to local conditions

## Spray generation

For PPP application basically three main principles to disperse the spray solution are utilized: hydraulic nozzles (nozzles and pressure), pneumatic atomization (droplets are generated by tearing a spray film at high air speed), spinning-disc atomizers (droplets are generated by centrifugal power).

The hydraulic nozzles are the most important in the EU. They exist in different designs and are able to provide different droplet spectra. As they are easily exchangeable, correct selection of the nozzles is a main drift-reducing mitigation measure. Pneumatic atomizers are mainly used in South Europe especially in plantations (orchard, vineyard etc.). With the technology available today, it is difficult to change the droplet spectra under practical conditions. Bigger drops will be generated if the air speed is reduced. On the other hand the air speed and air volume is important to transport the droplets to the target and to provide the necessary penetration of spray solution into the canopy.

Spinning-disc atomizers are hardly used in Europe. The droplet size in this case can be increased by reducing the disc speed.

In some EU countries nozzles are categorized according to their ability to reduce drift. The classification differs by country, is not yet harmonized and can influence PPP buffer zone distance requirements.

| BMP No. | Category | What to do | |
|---|---|---|---|
| 9 | Spray generation | Use nozzles with low amount of fine droplets (<100 µm) and use low pressure | |
| 10 | Spray generation | Use nozzles classified as drift-reducing according to the drift risk | |
| 11 | Spray generation | Use air induction nozzles in field crop sprayers | |
| 12 | Spray generation | Use air induction nozzles in orchard/vineyard sprayers | |

## How to do it: specification

- Use nozzles with droplet spectra appropriate to the diagnosed drift risk at low pressure (drift-reducing nozzles)
- Drift-reducing nozzles are necessary in cases of HIGH wind (3.1–5.0 m/s) and/or high application speed (>8 km/h)

Most countries classify drift-reducing nozzles by comparing them to a standard nozzle (e.g. flat fan 110 degrees, size 03, operating pressure 3 bar).

- Select nozzles according to your local classifications
- If a nozzle classification is not available/implemented in the country, the indications below may help in selecting the best nozzle

| Nozzle type | | Working parameters | Potential drift reduction vs. reference nozzle |
|---|---|---|---|
| Narrow angle flat fan or hollow cone |  | 1–4 bar | 10–20% |
| Flat fan pre-orifice |  | 2–5 bar | 30–50% |
| Flat fan air induction |  | 2–8 bar | 70–90% |
| Air induction end boom |  | 1–1.5 bar<br>2–2.5 bar<br>4–8 bar | 90%<br>75%<br>50% |
| Air induction hollow cone |  | 3–10 bar<br>10–15 bar | 75%<br>50% |

Air induction nozzles reduce spray drift by 50 to 90% compared to a conventional nozzle. Both nozzle types, flat fan and hollow cone, produce larger droplets by air induction, and are less prone to drift

- When selecting an air induction nozzle always check the correct pressure (see operations manual)
- Most PPP perform equally well with air induction nozzles. PPP manufacturers should be asked for advice in cases of doubt

Air induction nozzles reduce spray drift by 50 to 90% compared to a conventional nozzle. Both nozzle types, flat fan and hollow cone, produce larger droplets by air induction, and are less prone to drift

- Use air induction nozzles featuring a narrow spray angle to avoid clashing between adjacent spray jets
- In the case of a short distance (less than 50 cm) between nozzles and crop canopy, select air induction nozzles with a wider spray angle.

1 Must be implemented 2 Very important to follow 3 Important, specifications to be adapted to local conditions

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| 12 | | | • When possible, adjust the nozzle spacing and orientation on the sprayer according to the distance between the nozzles and the crop canopy in order to guarantee the necessary spray coverage<br>• Air induction hollow cone nozzles are especially recommended for conventional orchard/vineyard sprayers without deflectors<br>• Use these hollow cone air induction nozzles also for short distances between canopy and nozzles (narrow inter-row distance)<br>• Use air induction nozzles for spray applications at very early crop stages with low leaf area in combination with a reduction of the air volume, air speed and/or adjustment of air direction<br>• Most PPP perform equally well with air induction nozzles. PPP manufacturers should be asked for advice in cases of doubt |
| 13 | Spray generation | Reduce air speed in pneumatic atomizers | Under practical conditions, with the most sprayers in operation, a modification of the droplet spectra is difficult.<br>• One option is to reduce the air speed (pneumatic atomizers: thin layers of liquid are introduced into the fast air stream (80–120 m/s) and thus produce fine sprays (100 to 150 µm). The faster the air stream, the finer the droplets generated)<br>• Reduction of air speed needs to be balanced with the need for spray penetration into the canopy<br>• The second option to reduce the air stream velocity is to change the size of air spouts: the larger the spout outlet section, the slower is the air stream |

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| 14 | Spray generation | Reduce disc speed of rotary atomizers | In rotary atomizers the liquid is conveyed at low pressure to the centre of a spinning disc, which produces a fine spray due to its fast rotation. The faster the rotation speed, the finer the droplets generated.<br>Under practical conditions droplet size modification may be difficult as penetration into the canopy might be affected.<br>• Check the operator manual for detailed information |
| 15 | Spray generation | Use authorized drift-reducing adjuvant if recommended by chemical manufacturer | Drift-reducing adjuvants change the physical properties of the spray solution.<br>• Changes in the viscosity of spray solutions can have an influence on the droplet spectrum generated and on nozzle flow rate<br>• Correct adjuvant concentration is a critical factor for its drift reduction effect<br>• Hygroscopic substances can reduce the volatility of small droplets under low humidity situations<br>• Most PPP formulations are optimized and adding adjuvant is not recommended<br>• Check PPP label and manufacturer recommendation, if and how adjuvant should be added |

## Spraying equipment

Beside the correct use of PPP the spray equipment is the key element in drift reduction. For air-assisted sprayers in particular, it is necessary to evaluate the spray drift-reducing potential. It is important to take the following three aspects into consideration:

a) Droplet spectrum

b) Application technique and easy adjustment of sprayers (including air support)

c) Modification of sprayer parameters according to environmental factors and crop characteristics.
Some countries have started to classify sprayers according to their spray drift-reduction potential (known as Spray Drift-Reducing Technology (SDRT). The sprayers are divided into spray drift mitigation classes, e.g. 25%, 50%, 75%, 90%, 95% or 99% (see ISO 22369-1)

SDRTs are classified separately for different crop types, e.g. arable crop, fruit crop (dormant and full-leaf growth stage), hops, vineyard and nursery. In some countries, the use of SDRT results in modified distance regulations for the applied PPP. If there is no SDRT classification in your country the local recommendations on drift reduction measures have to be respected.

| BMP No. | Category | What to do |
|---|---|---|
| 16 | Spray equipment | Check the national SDRT classifications and the local recommendations |
| 17 | Spray equipment | Make an inventory of your sprayer to identify the drift-reducing potential |
| 18 | Spray equipment | Use application techniques allowing PPP reduction if appropriate |
| 19 | Spray equipment | Use sprayer classified as spray drift-reducing (SDRT) |
| 20 | Spray equipment | Use regularly inspected sprayers (regular testing will be required in all member states) |
| 21 | Spray equipment | Use/purchase sprayers which fulfil harmonized EN standards |
| 22 | Spray equipment | Use officially certified sprayers |

**How to do it: specification**

- Equip and adjust your sprayer according to the SDRT requirements and your application conditions
- Check the national recommendations to reduce drift

---

- Determine the SDRT class your sprayer represents
- Check in particular: sprayer type, nozzles, sprayer adjustment options, air support (speed, volume, direction), other features (e.g. shielding devices, sensors, etc.)

---

- Consider if it is possible to reduce the PPP drift and use, by adopting a more optimal application technique (e.g. spot treatment, band spraying, sensor spraying, weed wiper, etc.)

---

- Purchase sprayers which are classified as SDRT
- Upgrade your existing sprayer with nozzles, components and techniques to optimize spray drift reduction potential

---

In some countries regular sprayer testing is required and needs to be implemented by other countries where regular obligatory tests are not yet required.
(Reference: ISO 16122 and EU Directive 128/2009)

- If no testing scheme exists in your country have the sprayer inspected on a voluntary basis
- Pay special attention to equipment relevant for drift reduction (e.g. nozzles, hoses, pump, boom stabilizers, etc.)

---

Currently, EN standards are not obligatory to be respected. Be aware that currently harmonized EN standards are establis-hed, which will be obligatory.

- If purchasing a new sprayer ensure that the new harmonized standards are respected
- Non-branded equipment, whether purchased or self-made or modified, used to apply PPP, must comply with the same standards as EN-certified equipment supplied by machinery manufacturers

---

Preferably buy sprayers certified by a third party (e.g. according to ENTAM test protocol – European Network for Testing of Agricultural Machines, www.entam.net), which refers mainly to international standards

- Consider and consult drift mitigation Best Management Practices Guidelines when purchasing a new sprayer
- Be aware of sprayers which are environmentally friendly. Consult the TOPPS – EOS tool (www.TOPPS-life.org)

---

1 Must be implemented 2 Very important to follow 3 Important, specifications to be adapted to local conditions

| BMP No. | Category | What to do | |
|---|---|---|---|
| 23 | Spray equipment | Use sprayers equipped with section pressure compensation | |
| 24 | Spray equipment | Use sprayers with multi-nozzle bodies | |

## Sprayer adjustment

Sprayer adjustment is largely related to the behaviour of the operator and the adjustment options of the sprayer. According to the EU directive 2009/128 EC on the sustainable use of PPP, operators are obliged to regularly calibrate their sprayers. Calibration means: be sure that the sprayer can be operated according to the requirements of good agricultural practice.

a) Sprayer parameters should be adjusted and checked to apply the correct amount of PPP to the crop.

b) Correct adjustment of the sprayer means the potential losses of PPP to the environment are minimized (e.g. spray drift).

These checks should be performed several times during the season, because the crop composition changes (e.g. leaf areas of the crops in plantation crops). Also atomizers/nozzles are subject to deterioration.

| BMP No. | Category | What to do | |
|---|---|---|---|
| 25 | Sprayer adjustment | Calibrate your sprayer considering drift reduction | |

If a section of the boom needs to be closed (e.g. due to the shape of the field) pressure in the remaining section of the boom should remain stable.

- Pressure compensation units at the section valves keep pressure constant in each section of the spray boom (no change of droplet spectrum)

- Section pressure compensation units should be adjustable to the nozzle size in use

A multi-nozzle body equipped with different nozzle types allows for the selection of nozzles with different droplet spectra. The nozzle change can be either manual or automatic. Nozzle holders are available with up to five nozzles.

- Use multi-nozzle holders to easily adjust the droplet size according to the distance requirements to reduce drift

Note:
Colours of most of the nozzles (except hollow cone nozzle Albuz ATR) are ISO standardized according to flow rate and pressure. The ISO colours set the characteristics of the nozzles in terms of relation between output (l/min.) and pressure (bar). Note that this specification is not suitable for pneumatic sprayers.

## How to do it: specification

- Conduct regular calibrations of sprayer with water before spraying

- Consider especially environmental issues, e.g. spray drift reduction measures, low pressure, nozzles with coarse droplet spectrum (coarse spray nozzles) for windy conditions and/or for faster driving

**Field crop sprayers:**
- Driving speed should not exceed 6 km/h if standard nozzles are used

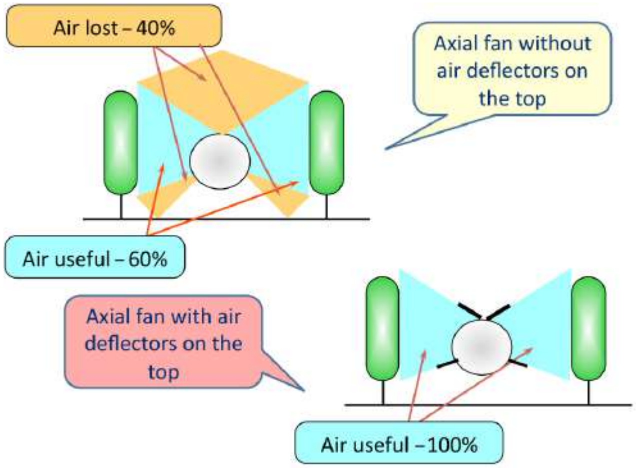
- For faster driving (>6 km/h) use coarse spray nozzles (air induction nozzles), air-assisted sprayers or other drift-reducing techniques

- Boom height should not exceed 50 cm

**Orchard/vineyard sprayers:**
- Optimize calibration adopting the most suitable number and configuration of nozzles matching the target profile

- Air flow, direction and air speed need to be adjusted to fit the size and geometry of the target to minimize losses (Fig. 5).

1 Must be implemented | 2 Very important to follow | 3 Important, specifications to be adapted to local conditions

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| | | |  <br>Fig. 5: Adjustment of air direction with and without deflectors.<br><br>• The calibration of fruit-and-vine sprayers should be visually checked in action by spraying clean water in orchard/ vineyard (Fig. 6)<br><br><br>Fig. 6: Test of correct adjustment of sprayer.<br><br>• Evaluate the spray penetration and distribution by visual assessment of coverage on water-sensitive paper located inside, under and over the crop canopies |

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| 26 | Sprayer adjustment | Use the lowest effective distance between nozzles/atomizers and the spray target | **Field crop sprayers:**<br>For flat fan nozzles the optimal distance is where the spray fan generated exactly covers the entire width with full overlap. The closer the nozzles are spaced on the boom, the shorter the effective distance to the target.<br>• Distance to the target depends on angle of the spray fan produced by the nozzle (e.g. 110-degree nozzles need a distance to target of 50 cm, 80-degree nozzles need a distance of 70 cm)<br>• Check the distance of the boom to the target before and during spraying also by means of indicators (as it is difficult to judge the boom height from the driver's seat)<br>• For band and row crop sprayers, adjust nozzles to cover the band/row while at the same time maintaining the lowest possible distance to target<br>**Orchard/vineyard sprayers:**<br>• Optimize spray application to reduce as much as possible the distance between the nozzles/spouts and the target by using specific and optimized settings (especially at early stages of the crop)<br>• For each treatment, the settings have to be adapted and optimized in order to suit crop development characteristics<br>• At early growing stages (e.g. vine) it is more relevant to reduce the number of rows sprayed (multirows) to be more precise and to reduce drift risk |

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| 27 | Sprayer adjustment | Use the lowest effective sprayer forward speed | At higher forward speed, the effective distance of the spray droplets to the targets increases (droplets are exposed to wind for a longer time). Increasing speed also increases the head wind and turbulence around the sprayer. This will leave more droplets in the air behind the sprayer and can be observed as a plume of "spray mist". Always aim for the smallest possible plume. If it is desired to increase the speed, the negative effects must be counteracted by other measures for **field crop sprayers**:<br>• Increase droplet size (drift-reducing nozzle)<br>• Lower the boom height<br>• Use air assistance<br>• Use shielded sprayers or crop tilters<br>For **orchard/vineyard sprayers**:<br>• Increase droplet size<br>• Carefully adjust the air flow rate; if this is difficult (e.g. pneumatic sprayers), then increase forward speed |
| 28 | Sprayer adjustment | Use the lowest effective pressure with hydraulic nozzles | • Read the recommendations of the nozzle manufacturer<br>• Use the lowest pressure possible (at lower pressures coarser droplets are produced, very fine droplets are minimized and hence risk of drift is reduced) |

### Sprayer operation

Sprayers should be operated so that only the target area is treated. This requires special attention at field boundaries and if necessary the use of drift-reducing measures.

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| 29 | Sprayer operation | Do not spray buffer zones and other non-target areas | • Check PPP label for required distance to water bodies and other sensitive areas<br>• In orchards/vineyards when spraying the outer row, close the nozzles on the side of the sprayer without canopy<br>• Stop spraying when turning at headlands<br>• For field crop sprayers switch off the boom sections applying PPP outside the target area<br>• For vineyard/orchard sprayers, especially for multi-row sprayers, a number of sections should be adaptable to the shape of the spray profile delivered by the sprayer (by shutting sections) and should fit the size of the field (for instance triangle shape)<br>• Be careful at the field margins and use drift-reducing technology |

1 Must be implemented 2 Very important to follow 3 Important, specifications to be adapted to local conditions

## METHODS TO REDUCE SPRAY DRIFT FROM FIELD CROP SPRAYERS

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| 30 | Sprayer adjustment | Use sprayers with effective boom stabilization systems | Booms without efficient stabilization tend to swing according to uneven field surface. The higher the boom is swinging, the higher the drift risk.<br>• Use booms with shock absorbers, movement dampers or anti- yaw systems<br>• Lower the pressure of the tyres to absorb uneven soil surface, check tyre manufacturers' recommendations |
| 31 | Sprayer adjustment | Adjust air-flow velocity in air-assisted sprayers according to application conditions | • For air-assisted sprayer used on bare soil, or soil with poor plant cover reduce the air speed (minimize turbulence and formation of dust)<br>• Increase the air flow as the demand of the spray liquid to penetrate the crop canopy increases<br>• Check operators' manual to adjust the air flow to the application conditions |
| 32 | Sprayer adjustment | Adjust nozzle/air-assistance direction (change spray angle) according to application conditions | • In case of headwinds: angle towards driving direction<br>• In case of downwind: angle against the driving direction<br>• If side wind/no wind, angle vertical or against the driving direction. Only high forward speed may require forward angling in this case<br>• The recommendation for angling according to the crop is: bare ground/low vegetation: angle back to avoid reflection of spray liquid<br>dense crop: follow the crop movement as you vary the angle. At certain settings, the crop will open up which favours penetration of the spray into the canopy<br>• If wind speed, wind direction or forward speed changes, the optimum angling of nozzles will probably change too. Therefore, always pay close attention to the application conditions<br>• Check operators' manual for further descriptions on how to find the optimal angling under certain conditions |

## METHODS TO REDUCE DRIFT FROM FRUIT CROP SPRAYERS

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| 33 | Environmental factors | Use hail nets also as barriers to prevent spray drift | Hail nets are able to reduce drift by reducing the extension of the spray cloud. |
| 34 | Spraying equipment | Do not use cannon sprayers next to sensitive areas | Cannon sprayers produce an uncontrollable spray cloud exposed to wind, and hence pose a high risk of drift.<br>Cannon sprayers should not be used in areas where spray drift may cause risks. Should the use of this kind of sprayer be unavoidable, be aware of sensitive areas close to the sprayed field and take all precautionary measures into account to reduce spray drift. |
| 35 | Spraying equipment | Use sprayers with adjustable air jet direction (orientation to target) | The following types of sprayers feature the target-oriented properties:<br>Cross-flow sprayers with air deflectors or towers with air spouts (Fig. 7)<br>Directed air-jet sprayers with flexible air ducts and adjustable air spouts (Fig. 8)<br><br>Fig. 7: Crossflow with air deflectors.<br><br>Fig. 8: Air jet sprayer with adjustable spouts.<br>• Make use of devices and adjustment features of the sprayer to apply spray precisely according to the canopy size, geometry and density<br>• Avoid off-target spray loss (spraying over or under the crop canopies). |

1 Must be implemented 2 Very important to follow 3 Important, specifications to be adapted to local conditions

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| | | | Use sprayers which offer appropriate setting of nozzle position and orientation, adjustment of the air-flow direction and velocity, and the spray liquid output (opening/closing of the appropriate number of nozzles/spouts).<br><br>In order to achieve uniform deposition and reduced drift with these types of sprayers the following rules should be observed:<br><br>• Open appropriate number of nozzles to avoid spraying above and underneath the crop canopy<br><br>• Set the nozzle position and orientation to achieve uniform spray distribution along the canopy profile<br><br>• Adjust the air-flow deflection and velocity according to the canopy width and density to avoid spray being blown through the canopy<br><br>The correct adjustment of the air-jet direction is achieved when the crop canopy is fully penetrated by the spray and no spray cloud is observed on the other side of the crop row.<br><br>• Make visual assessment of the air-flow adjustment in the plantation with clean water prior to the PPP application to check penetration<br><br>• Use greater backward air-flow deflection at early growth stages, for narrow and open canopies, and in low wind situations<br><br>• Use less or no backward air-flow deflection for taller and denser crop canopies when using higher sprayer air velocities and in stronger winds<br><br>• In crosswind situation drive closer to the windward (upwind) row of the crop |
| 36 | Spraying equipment | Use sprayers with adjustable air-flow velocity | Adjust air-flow velocity according to the target size, geometry and crop stage.<br><br>This can be done by:<br><br>• Appropriate angling of blades of the fan propeller<br><br>• Adjustment of the rotation speed (RPM) of the propeller by the appropriate gearbox setting |

| BMP No. | Category | What to do | How to do it: specification |
| --- | --- | --- | --- |
| | | | • Adjustment of the power take-off (PTO) of the tractor engine.<br>The air-flow velocity should be adjusted and correlated with the driving velocity of the sprayer to obtain full air penetration within the canopy volume. This is achieved when the crop canopy is fully penetrated by spray, and yet no spray cloud is observed on the other side of the crop row (ref. BMP No. 36)<br>• Use lower air-flow velocities at early growth stages as well as narrow and open canopies<br>• Use higher air-flow velocities for bigger and denser crop canopies, at higher sprayer velocities and in stronger winds<br>• During the crosswind situation drive closer to the windward (upwind) row of the crop |
| 37 | Spraying equipment | Use sprayers equipped with a system to close the air flow on either side | • In order to avoid blowing spray through the crop canopy out of the target area, when spraying the outer row of the plantation, the use of a sprayer which can close air outlets on either side (right and left) is recommended (Fig. 9).<br><br>Fig. 9: Sprayer to close air outlets on each side. |

1 Must be implemented 2 Very important to follow 3 Important, specifications to be adapted to local conditions

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| 38 | Spraying equipment | Use sprayers with individually controllable nozzles | • Adjust sprayer settings to canopy development (especially for early stages) by adapting the number of active nozzles.<br>• Shut off nozzles which are not oriented to the crop (manual, automatic adjustment).<br>• Nozzle shut-off could be used also for vertical band application (specific level of crop canopy).<br>• Consider that shutting off nozzles changes the volume rate applied and requires new measurements and/or calculation to prepare the correct PPP concentration of spray mixture. |
| 39 | Sprayer adjustment | Adjust the spray profile to target characteristics | • Try to obtain a spray profile matching as much as possible the vegetation profile.<br>• Use Water Sensitive Paper (WSP) to get indications on inside, outside and vertical profile spray penetration of the canopy with certain nozzle/spout/outlet adjustments.<br>• Vertical patternators can be used to select/adjust the most appropriate spray profile.<br>• Adapt the nozzle/spout settings (position and direction) on the sprayer to the crop-training system and according to the crop growth stage. |
| 40 | Sprayer adjustment | Adjust air-flow velocity/ direction according to application conditions | • Avoid excessive air flow and speed causing high drift risks in crops with little leaf cover/early stages.<br>• Change air speed by selecting lower propeller speed by changing gearbox adjustments.<br>• Change the angling of the blades on axial fan sprayers and correctly orient the air deflectors, so that the air flux matches the canopy profile.<br>• When spraying plants at early growth stages (no leaves) consider the option of switching off air support. |

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| 41 | Sprayer adjustment | Adjust forward speed to air-flow volume and velocity | The amount of air hitting the target should be tuned to maximize spray penetration into the canopy while limiting spray drift risks due to droplets passing through the sprayed rows.<br>• General indication: air velocities hitting the target should be adjusted to 6–8 m/s in vineyard (full leaf development) and to 10–12 m/s in orchard (full leaf development)<br>• The air-flow velocity should be adjusted with the driving velocity of the sprayer (crop canopy fully penetrated by spray, no spray cloud is observed on the other side of the crop row) ref. BMP 36 |
| 42 | Sprayer adjustment | Close or reduce air-flow blowing outwards when spraying at the edge of the plantation or towards sensitive areas | • Use the air closure systems on the side of the sprayer when approaching field boundaries or sensitive areas so that droplets are not conveyed out of the sprayed field<br>• Consider the adoption of automatic systems to manage the air flow rate independently on the two sprayer sides (closed/unclosed)<br>• Reduce fan speed when spraying the outer rows of the orchard/vineyard. See also BMP No. 38 |

1 Must be implemented 2 Very important to follow 3 Important, specifications to be adapted to local conditions

## ADDITIONAL SUGGESTIONS TO REDUCE DRIFT FROM FIELD CROP SPRAYERS

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| A1 | Spray generation | Use twin fluid nozzles | • Use twin fluid nozzles to allow changing of flow rate and droplet size independently.<br>• Droplet size can be adjusted to produce a coarse spray at field edges next to sensitive areas.<br>Note that spray cross distribution from twin fluid nozzles tend to get more uneven if droplet size is increased too much. Follow manufacturer's instructions carefully. |
| A2 | Spray generation | Use deflector nozzles for application on bare soil | For applications on bare soil (pre-emergence treatments), consider the use of deflector nozzles producing coarser droplets. Deflector nozzles feature a wide spray pattern and good overlapping between spray jets. Therefore boom height can easily be lowered. |
| A3 | Spraying equipment | Use air-assisted field crop sprayer on established crops | • Air assistance counteracts the effects of windy conditions and wind generated from driving.<br>• Air assistance can be used to prolong the period of acceptable spraying conditions.<br>Air-curtain sprayers have a spray boom equipped with fan and air sleeve producing a downward air flow of 1,400 to 2,000 $m^3/h/m$ supporting the transport of the droplets to the target. Note: Potential drift reduction of up to 75% in combination with air induction nozzles; 50% with conventional flat fan nozzles. |
| A4 | Spraying equipment | Use shielded field crop sprayers | • Use a shielded boom (droplets are protected from wind for a certain distance, whereby the effect of wind is reduced)<br>• Shields can also be designed to deflect the air flow and direct the droplets towards the ground.<br>• Another way of shielding is to form a row tunnel in bed-grown crops. |
| A5 | Spraying equipment | Use crop-tilter field crop sprayers | • Crop tilters are especially useful for applications in cereal crops if a deep penetration of the chemical is required. These devices bend the plants under the spray boom in order to produce a gap for the spray to penetrate.<br>Note: Designed as a shield (Släpduk) sliding on the canopy has a drift-reducing potential of 90% with air induction nozzles; 75% with conventional flat fan nozzles. Follow manufacturer's instructions carefully. |

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| A6 | Spraying equipment | Use band field crop sprayers | Use a band sprayer where appropriate.<br>Note: Band sprayers can be used to minimize the rate/area of a pesticide. Normally, these sprayers are combined with seeders or implements for mechanical weed control. Special nozzles (even spray nozzles; 60–80° spray angle) are usually used for band sprayers. |
| A7 | Spraying equipment | Use shielded band field crop sprayers for row crops | • Shielded band sprayers can be used to minimize the use of PPP/area, by applying the product solely within the row<br>• They are also used for non-selective weed control between rows, the shield protects the crop in the row |
| A8 | Spraying equipment | Use sensor field crop sprayers (target identification system) | Sensor sprayers equipped with target identification systems, such as the GreenSeeker, can detect target plants/area with leafves.<br>Sensors open spray nozzles individually only if leaf area is detected. |
| A9 | Spraying equipment | Use automatic boom height control systems | Especially for wide booms, automatic height-adjustment sensors ensure that the intended boom height can be maintained under most conditions. |
| A10 | Spraying equipment | Use GPS-controlled sprayers | Use of GPS allows:<br>• Automatic nozzle shut-off at headlands (when turning)<br>• Automatic adjustment of specific sprayer settings (e.g. pressure, type of nozzle, number of active nozzles, air flow rate) on the basis of sprayer position in the field (e.g. in the proximity of sensitive areas).<br>Note: Precision farming technologies in crop protection are expected to be more and more used in the future; therefore users/advisers are encouraged to stay up to date on the subject. |
| A11 | Spraying equipment | Use weed-wiper for selective weed control | A weed-wiper can be used to control weeds if taller than the crop. The weed-wiper eliminates drift, as droplets are not generated.<br>Note: Only specific applications. |

1 Must be implemented 2 Very important to follow 3 Important, specifications to be adapted to local conditions

## ADDITIONAL SUGGESTIONS TO REDUCE DRIFT FROM FRUIT CROP SPRAYERS

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| B1 | Spraying equipment | Use shielded sprayers with a recycling system (tunnel sprayers) | The following types of sprayers featuring shielded spraying properties reduce spray drift by reducing the effect of wind on droplets during application:<br>a) Conventional tunnel sprayers<br>b) Tunnel sprayers with spray separators (lamella filters)<br>c) Over-the-row sprayers with spray separators (lamella filters)<br>d) Over-the-row sprayers with reflector shields<br>These sprayers may also be equipped with recirculation systems minimizing ground losses and resulting in spray savings.<br>Consider when using shielded recycling sprayer:<br>1) Spray mixture recovery is high at early growth stages<br>2) Spray losses can be recovered e.g. in case of missing plants<br>• Tunnel sprayers, or sprayers fitted with panels, allow the applied spray volume and the risk of drift to be reduced. It is recommended to use air induction nozzles in particular with a flat fan pattern.<br>• Consider that using a tunnel sprayer may result in high volumes of residual spray in the tank due to the fact that the quantity of spray mix to prepare is not simple to estimate.<br>• Using a tunnel sprayer requires efficient residual spray management to prevent converting drift reduction into point source pollution. |

| BMP No. | Category | What to do | How to do it: specification |
|---|---|---|---|
| B2 | Spraying equipment | Use (multi-) row-covering sprayers | In order to achieve uniform deposition and reduce drift with multi-row sprayers the following rules should be followed:<br>• Use a multi-row sprayer spraying complete rows (i.e. covering two complete rows is better than four semi-rows).<br>• Use the same number of nozzles and orientation on both sides of the row.<br>• Maintain uniform distance from the nozzles to the canopy all along the canopy profile (height).<br>• If spraying simultaneously on both sides of the row adjust the nozzles and airstreams in order to create turbulence inside the canopy and improve spray deposition.<br>• Avoid blowing the spray through the canopy. |
| B3 | Spraying equipment | Use sensor-controlled sprayers | • The use of sensor target detection (presence/absence of leaf area) prevents spraying in the gaps, exposing the spray cloud to the wind.<br>• Sophisticated sensors identifying canopy geometry and density allow for even further drift reduction, by adjusting the spray volume to the actual canopy structure. |
| B4 | Spraying equipment | Use GPS-controlled sprayers | Use of GPS allows:<br>• Automatic nozzle shut-off at headlands (when turning)<br>• Automatic adjustment of specific sprayer settings (e.g. pressure, type of nozzle, number of active nozzles, air flow rate) on the basis of sprayer position in the field (e.g. in the proximity of sensitive areas).<br>Note: Precision farming technologies in crop protection are expected to be more and more used in the future; stay up to date on the subject. |

1 Must be implemented 2 Very important to follow 3 Important, specifications to be adapted to local conditions

## A

**Adjuvant –**
substance without primary biological activity but able to improve the biological efficacy of the active ingredients. In this context it may also be a substance that increases the viscosity of the spray solution and thereby acting as drift-retardant.

**Air assisted field crop sprayer –** see air curtain sprayer.

**Air curtain sprayer –**
field crop sprayer equipped with hydraulic nozzles and a fan whose air flow is conveyed along the boom through an air sleeve (Fig. 10). Air is addressed downwards towards the crop/soil and has both functions to convey droplets to target and to reduce the trail of droplets suspended in the atmosphere behind the boom.

Fig. 10: Boom sprayer with air support.

**Air induction nozzle –**
hydraulic nozzle (see definition) provided with small orifices along its body enabling the suction of air within the liquid flux (Fig. 11); the mixing of air and liquid allows the production of droplets containing air bubbles, therefore coarser droplets with respect to the ones produced by conventional nozzles. Air induction flat fan and hollow cone nozzles (see definitions) are both available on the market.

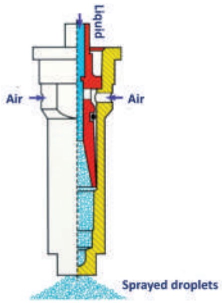



Fig. 11: Air induction nozzles.

**Air flow rate –**
volume of air flowing through an appliance per unit of time (ISO 5681), typically expressed in $m^3/h$ or $cm^3/s$. It mainly depends on the fan size, fan rotation speed and fan blade angle: the larger the fan size and blade angle and/or the higher the rotation speed, the higher the fan air flow rate.

**Angling nozzle –**
to orient nozzles towards a defined direction (e.g. on field crop sprayers to orient nozzles backwards or forwards perhaps in combination with air-assistance according to wind direction).

## B

**Band sprayer –**
machine that applies spray liquid in bands or rows (ISO 5681). Typically used on row crops or to apply herbicides under the vineyard/orchard rows.

**Boom sprayer –** see field crop sprayer.

### Buffer zone –
an area of a defined width along the field boundary that is preferably not cropped and is not directly sprayed; it has the function of preventing adjacent sensitive areas from spray drift contamination (Fig. 12).

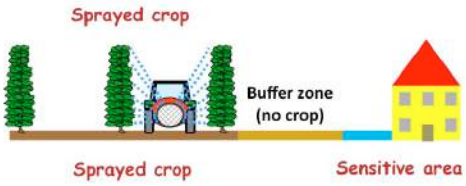



Fig. 12: Buffer Zone to protect sensitive area.

## C

### Cannon sprayer –
sprayer type generally used for application on high trees, but sometimes also for application on developed maize plants, that consists of a radial fan conveying the air towards a single big air outlet; hydraulic nozzles are positioned along the contour of the air outlet so that the spray is propelled by a high-velocity air current which projects the droplets at distances of some dozens of metres from the spraying machine. This type of spraying equipment produces uncontrollable spray clouds, very prone to drift (Fig. 13).

Fig. 13: Cannon sprayer, very vulnerable to drift.

### Calibration –
measurement of sprayer output, and sprayer setting with the correct spraying parameters (e.g. nozzle size, operating pressure, forward speed, air flow rate) in order to match the prescriptions of good agricultural practice. It should be made after checking the proper sprayer functionality (e.g. nozzle flow rate, absence of leakages, anti-drift device functionality, etc.).

### Crop tilter –


rigid bar mounted below the boom sprayer (Fig. 14) that opens the crop as it passes through.

Fig. 14: Crop tilter opens crop for better spray penetration.

## D

### Deflector –
thin plastic or metal adjustable sheet, positioned adjacent to the fan air outlet, enabling the adjustment of the air outlet direction. They are typically mounted on fruit crop sprayers. Depending on the fan air conveyor type, one or more pairs (left and right side) of air deflectors may be present.

Fig. 15: Deflector nozzle.

### Deflector nozzle –
hydraulic nozzle (see definition) where droplets are generated by a small deflector into the nozzle body and then rebound towards the ground. These nozzles create a coarse droplet size with low kinetic energy and are typically used for application on bare soil (Fig. 15).

**Diffuse source –**
in the context of TOPPS Prowadis, this is mainly related to undesired movement of PPPs in soil, water or air following application on crops, and within areas agreed for use according to approved label recommendations. Examples of diffuse sources include leaching, drainage, soil erosion and/or run-off, and spray drift following approved field applications.

**Drift reduction classes –**
according to ISO 22369-1 spraying equipment can be classified according to drift risk comparing the drift generated by candidate spraying equipment with the drift generated by a reference standard. Drift reduction classes are the following:

| Class | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| % of drift reduction | >99 | 95–99 | 90–95 | 75–90 | 50–75 | 25–50 |

In several EU countries some nozzles and some sprayers are officially classified as "drift-reducing" according to the ISO 22369-1 classes.

**Droplet –**
Substantially spherical liquid particle with a diameter generally less than 1,000 μm (ISO 5681).

**Droplet size –**
parameter to categorize the spray quality. Typically the following parameters are used: 1) Volume Median Diameter (VMD), which is the diameter (expressed in μm) which divides a population of droplets in two parts of equal volume; 2) D10, which is the diameter (in μm) below which it is represented by 10% of the total volume of a population of droplets; 3) D90, which is the diameter (in μm) below which it is represented by 90% of the total volume of a population of droplets. The higher the VMD, the coarser the droplets. Even if there is not a specific standard about this subject, six categories of droplet sizes have been defined by the British Crop Protection Council (BCPC) and are internationally recognized: a) very fine (<150 μm), b) fine (150÷250 μm), c) medium (VMD 250÷350 μm), d) coarse (350÷450 μm), e) very coarse (450÷550 μm), f) extremely coarse (>550 μm).

**Droplet spectrum –**
distribution of droplet sizes in a population of droplets.

## E

**EU Directive –**
it is the establishment of laws, regulations and administrative provisions by the European Union. It covers all member states of the EU and is binding in its goals to achieve the content. However it gives the Member States freedom in HOW to achieve the goals, the so called principle of subsidiarity. This takes into account the natural and socio-economic differences between the regions of the Union. It means that for many directives local, regional or national variation in implementation might occur and member states might add insofar as those differences do not detract from the Directives' framework.

## F

**Field crop sprayer –**
spraying machine featuring a horizontal boom equipped with nozzles suitable to apply PPP on low herbal crops (e.g. winter wheat, barley, maize, potatoes, tomatoes, horticultural plants, etc.); spray is expressed downwards from a horizontal plane.

**Flat fan nozzle –**
hydraulic nozzle (Fig. 16) featuring an elliptical orifice, which produces a flat triangular-shaped jet; typically used on field crop sprayers, it is also used on fruit crop sprayers. For most of spray application the spray angle of flat fan nozzles ranges between 80° and 120°; narrower spray angles are used for special application (e.g. band spraying).

Fig. 16: Flat fan nozzle.

**Fruit crop sprayer –**
spraying machine generally featuring a fan and semicircular or vertical booms, present on both sides of the sprayer, equipped with nozzles suitable to apply PPP on arboreal and bush crops (e.g. apple/pear/peach/plum orchards, citrus trees, olive trees, vineyards, etc.); spray is expressed towards the vegetation canopy along a vertical plane.

**Full cone nozzle –**
hydraulic nozzle (Fig. 17) featuring a circular orifice and producing a cone jet which produces a full circular footprint.

Fig. 17: Full cone nozzle.

## H

**Hail net –**
net generally made of nylon which, especially in Southern Europe, is placed over orchards and vineyards mainly to prevent damage due to the impact of hail particles on fruits and bunches. Its presence when spray application is carried out may act as an air curtain barrier to contain dispersion of droplets out of the applied field.

**Hydraulic nozzle –**
part or an assembly of parts with an orifice through which the liquid is forced under pressure to produce a spray (ISO 5681). The higher the pressure and the smaller is the orifice, the finer are the droplets produced. In the range of hydraulic nozzles there are different categories: flat fan nozzles, hollow cone nozzles (both conventional and air induction types), deflector nozzles, full cone nozzles (see specific definitions).

**Hollow cone nozzle –**
hydraulic nozzle (Fig. 18) featuring a circular orifice and equipped with a swirl chamber where liquid rotates before exiting the orifice. It generates an empty cone jet which produces a circular footprint (empty inside the circle). Spray angle is typically 80° and such types of nozzle are mostly used on fruit crop sprayers, sometimes also on field crop sprayers.

Fig. 18: Hollow cone nozzle (orchard/vineyard)

## L

**Layout –**
for arboreal crops, the spatial disposal of plants in the field (e.g. an orchard having a layout of 4.5 x 1.5 m features a distance between rows of 4.5 m while spacing between trees along the row is 1.5 m).

## M

**Mitigation measures –**
actions aimed at preventing environmental contamination from spray drift. For example, use of devices and sprayer settings enabling reduced drift generation at source (direct measures); adoption of buffer zones, establishment of natural or artificial windbreaks, use of hail nets with the aim of reducing the exposure to drift of the areas adjacent to the applied field (indirect measures).

**Multi-row sprayer –**
in the range of fruit crop sprayers, a machine able to apply four or more rows in one single pass (Fig. 19).

Fig. 19: Multi-row sprayer, a) with nozzles; b) with spouts.

## N

**No spray zone –**
part of the cultivated field that must not be directly sprayed to prevent risks of environmental contamination. Typically, it can correspond to the downwind border of the field.

**Nozzle –**
sprayer component producing the droplets, which create the spray plume expressed towards the target. Depending on the mechanism of droplet generation, three main general categories of nozzles can be distinguished: 1) hydraulic nozzles; 2) pneumatic atomizers; 3) spinning disc (rotary) atomizers (see corresponding specific definitions).

## O

**Orchard sprayer –** see fruit crop sprayer

**Over-the-row sprayer –**
fruit crop sprayer equipped with a structure passing over the row and fitted with vertical elements holding nozzles and air spouts to spray both sides of the row at the same time (Fig. 20).

Fig. 20: Over-the.row sprayer.

# P

### Pneumatic atomizer –

in pneumatic sprayers, droplets are generated by air shear of the liquid, and then sprayed out. It generally consists of a single spout or multiple spouts where the air generated by the fan is conveyed at high velocity (>100 m/s). Liquid is also conveyed in the body of the spout at low pressure (1–2 bar) and the droplets are generated by the action of the air which shears the liquid. The higher the air velocity, the finer the droplets produced (Fig. 21).

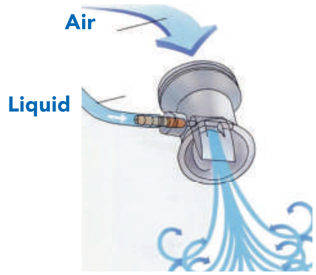



Fig. 21: Pneumatic atomizer.

### PPP label –

information and technical notes about chemical composition, recommended doses, instructions for use and safety precautions that must be reported on the stickers applied on PPP cans. Usually, this information represents a summary of more detailed technical notes which are reported in the safety sheet which must always be delivered by dealers together with the PPP cans.

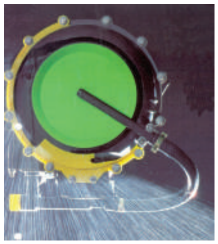
### Pressure compensation –

system of valves in the hydraulic circuit of the sprayer which enables the operating pressure to remain constant independent of the number of hydraulic sections which are open. The adjustment of the pressure compensation valves has to be made according to the nozzle size used on the sprayer.

# R

### Recycling sprayer –

multi-row or over-the-row sprayer (see specific definitions) typically operated in orchards and vineyards, provided with shields or tunnel systems for preventing dispersion of droplets out of the applied rows, able to collect the liquid which passes through the rows and to reuse it for spray application.



### Rotary atomizer –

sprayer component consisting of a spinning disc whose perimeter is indented. The disc rotates at high speed thanks to an electric motor while the liquid is conveyed at low pressure (1–2 bar) in the centre of the disc. Centrifugal force addresses the liquid on the disc perimeter where it is fragmented in droplets. In this case, the droplet spectrum is even because all droplets have the same size, which is determined by the disc rotation speed: the higher the speed, the finer the droplets. These kinds of atomizers can be mounted either on field crop or on fruit crop sprayers and allow the application of very low volume rates (Fig. 22).

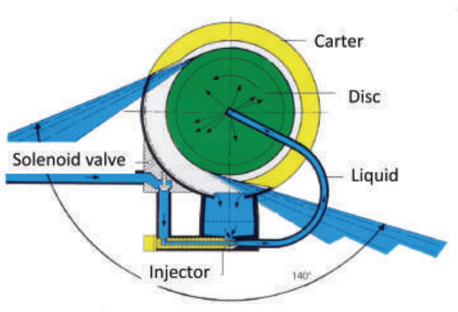



Fig. 22: Rotary atomizers.

# S

**Sensitive area –**
area located in proximity to the applied field, whose eventual contamination from PPP could result in risks for the environment and humans (e.g. natural parks, children's playgrounds, urban areas, water sources for extraction of drinkable water, water bodies, etc.).

**Shielded sprayer –**
sprayer provided with covers to contain the dispersion of droplets around the nozzles/atomizers. Shields can be present either on boom sprayers used on field crops (Fig. 23a) or on band sprayers used along crop rows (also in vineyards and orchards, Fig. 23b) or on fruit crop over-the-row sprayers (Fig. 23c).


a


b


c

Fig. 23: Various shielded sprayers.

**Spinning disc atomizer –** see rotary atomizer.

**Spray angle –**
angle formed close to a spray nozzle by the edges of the spray (ISO 5681). It is expressed in degrees.

**Sprayer configuration –**
the combination of spraying parameters used for an application. For example, for field crop sprayers the combination of nozzle type and size, operating pressure, boom height and forward speed; for fruit crop sprayers, the combination of nozzle type, size and orientation.

**Spray coverage –**
ratio of the target surface area covered by the spray droplets to the total target surface area (ISO 5681).

**Spray distribution –**
repartition of droplets sprayed on the target surface; it can be visualized with the aid of water-sensitive paper (see specific definition).

**Spray cross distribution –**
the spray pattern obtained with field crop sprayers, which can be measured by ad hoc test benches collecting the liquid sprayed under the boom (see Fig. 24).

Fig. 24: Equipment to measure the quality of the cross-distribution of the spray.

**Spray drift –**
the quantity of plant protection products that is carried out of the sprayed (treated) area by the action of air currents during the application process (ISO 22866).

**Spray Drift Reducing Techniques –**
devices, adjuvants and sprayer components which are useful to prevent the generation of spray drift by increasing the average droplet size (e.g. air induction nozzles, anti-drift adjuvants, etc.) or by preventing dispersion of spray out of the applied field (e.g. air curtain sprayers, shields, tunnels, etc.). Consult website www.sdrt.info to see an overview of SDRT recognized in the different EU countries.

**Spray penetration –**
spray entering and being deposited within the inner part of the canopy foliage (ISO 5681).

**Spray scenario –**
the combination of sprayer configuration, sprayer setting, crop characteristics and features of areas surrounding the field of application which determines the severity of drift risk.

**Sprayer adjustment –** see calibration.

**Sprayer types –**
categories of sprayers (Fig. 25). General sprayer categories can be defined according to the liquid generation system (hydraulic sprayers, pneumatic sprayers, centrifugal sprayers) or according to the target (field crop sprayers, fruit crop sprayers). In the range of a single general category, different subcategories can be defined.

For example, within field crop sprayers:
a) Air curtain sprayers
b) Conventional hydraulic boom sprayers
c) Pneumatic boom sprayers (see also specific definitions)

Within fruit crop sprayers
(see examples in Fig. 25):
a) Conventional axial fan air-assisted sprayers
b) Tower-shaped air-assisted sprayers
c) Multi-spout air-assisted sprayers
d) Multi-row sprayers
e) Over-the-row sprayers
f) Tunnel sprayers
g) Cannon sprayers
(see also specific definitions).

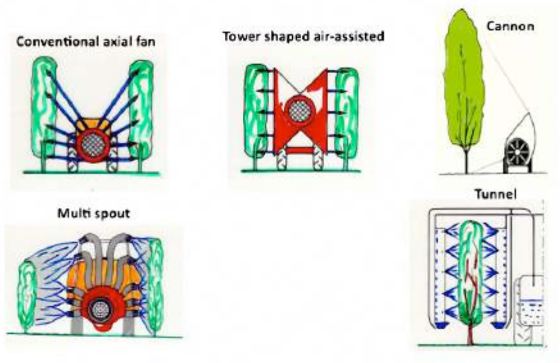



Fig. 25: Various sprayer types used in orchards and vineyards.

**Standard –**
a published specification that establishes a common language and contains a technical specification or other precise criteria and is designed to be used consistently, as a rule, a guideline, or a definition at national (country standard) European (EN standard) or international (ISO standard) level. A standard is in most cases NOT legally binding. A "directive" (see EU directive) specifies the objective result in rather general terms and this is binding. The link between "EU directives" and some harmonized "EN standards" is indirect. Application of EN harmonized standards gives presumption of conformity. This means that if equipment fulfils certain EN harmonized or ISO standards, EU presumes that this is in conformity with the legal requirements on the included aspects.

## T

**Training system –**
in arboreal crops, the way how shoots/branches are positioned and pruned along the rows. Examples for vineyards are: Alberate, Cordon trained, Guyot, Sylvoz, Tendone, T-trellis, V-trellis. Examples for orchards are: Palmetta, Spindelbusch, Vaso, Y-system.

**Tunnel sprayer –**
sprayer mainly designed for arboreal crops (Fig. 26) provided with a structure overcoming the row and equipped with panels to contain the spray dispersion out of the row applied. Panels may also be equipped with a system for recycling the captured liquid.

Fig. 26: Tunnel sprayer.

**Twin fluid nozzle –**
appliance in which the spray is produced by the action of a high-velocity airstream on the spray mixture (ISO 5681) (Fig. 27).

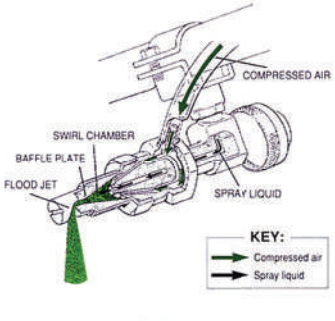



Fig. 27: Twin fluid nozzle.

## V

**Vertical patternator –**

device enabling the collection of water sprayed from fruit crop sprayers along the vertical plane so as to assess their vertical spray profiles (Fig. 28).

Fig. 28: Equipment to measure the vertical spray distribution.

**Volume application rate –**
volume (or mass) of spray liquid or formulated product applied per area treated (ISO 5681). It is generally expressed in L/ha.

## W

**Water body –**
any surface water (flowing or not) exposed to spray drift contamination (e.g. lakes, ponds, basins, rivers, streams, ditches, springs, etc.).

**Watercourse –**
water body featured by flowing water (e.g. rivers, streams, ditches, etc.).

**Water-sensitive paper –**
strips of special paper which reacts and changes its colour on contact with water. Typically used as indicators for assessing target spray coverage.

## Z

**Zone of awareness –**
it is the buffer zone distance requirement given in the label of the PPP intended to be applied, plus for:

a) Field application: the distance corresponding to a boom working width, or at least 20 metres
b) Orchard/vineyard applications: the distance corresponding to 5 rows, or at least 20 metres

## LIST OF ABBREVIATONS

**BMP –** Best Management Practices

**ECPA –** European Crop Protection Association

**EN –** it indicates standards issued by CEN (European Committee of Normalisation)

**ENTAM –** European Network for Testing of Agricultural Machines

**ISO –** it indicates standards issued by International Organization for Standardization

**PPP –** Plant Protection Products

**SDRT –** Spray Drift Reducing Techniques

**TOPPS –** Train Operators to Promote Practices and Sustainability

**Prowadis –** Protect water from diffuse sources

## REFERENCES


ISO – 22866

ISO – 22369

ISO – 16122

ISO – 5681

EU – Directive 128/2009/EC

TOPPS
PROWADIS

European
Crop Protection

European Crop Protection Association
E.C.P.A.
6 Avenue E. Van Nieuwenhuyse,
B-1160 Brussels, Belgium.
tel: +32 2 663 15 50
fax: +32 2 663 15 60
ecpa@ecpa.eu