INTERNATIONAL STANDARD

ISO 22866

First edition
2005-06-15

Equipment for crop protection — Methods for field measurement of spray drift

Matériel de protection des cultures — Mesurage de la dérive du jet au champ

Reference number
ISO 22866:2005(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22866 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 6, *Equipment for crop protection*.

Equipment for crop protection — Methods for field measurement of spray drift

1 Scope

This International Standard establishes principles for the measurement of droplet drift from all types of equipment designed for applying plant protection products. Detailed specifications relate to tractor-mounted, trailed and self-propelled agricultural sprayers operating in arable field crops (boom sprayers) and in bush and tree (including vines, hops, fruit) crops (including broadcast air-assisted sprayers).

The principles are also applicable for any hand-held equipment or aircraft, but detailed protocols for such systems are not included in the specifications defined.

All measurements are made with the sprayer operating outdoors in typical field conditions or over a defined surface including grass turf. Crop conditions include all arable (field) and horticultural crops that would be treated with a boom sprayer. Measurements of the crop and basic meteorological conditions at the time of spraying are made as part of the test procedure.

This International Standard specifies the making of field measurements so as to determine the quantities of spray drift during application at defined distances from a treated area for risk assessment purposes. Standard measurement distances are defined that are used to enable the results from different experiments to be compared.

Measures of drift can relate to either the deposition of spray onto horizontal surfaces outside of the treatment area or to airborne spray profiles that can be characterised at given downwind distances downwind of the treatment area. Deposition onto horizontal surfaces is relevant to the assessment of the risk of contamination of, for example, surface water; whereas the measurement of airborne profiles are relevant to risk assessments relating to inhalation effects and to the contamination of, for example, vegetative structures at field boundaries. This International Standard is applicable to both situations, although the emphasis in any series of trials may be varied by selection of the sampling matrix to be used.

Where comparative assessments of the relative drift risk from different application systems are needed, then this International Standard is applicable, but some requirements relating to the use of reference spraying systems, collectors, selection and definition of the trial site may need to be modified. A description of such modifications is included, where appropriate.

Drift measurements relate to application conditions aimed at achieving realistic levels of deposit on a target within the sprayed area. Since drift is commonly expressed as a proportion of the application rate, it is important that some direct assessments of target deposits be made as part of the drift measurement procedure.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
spray drift
quantity of plant protection product that is carried out of the sprayed (treated) area by the action of air currents during the application process

NOTE Material applied which escapes from deposits on treated plants or the ground after application is not regarded as spray drift. Drifting material may take the form of droplets, as dry particles or as vapour. However, this International Standard is only concerned with the sampling and estimation of droplet drift.

2.2
swath width
working width of boom sprayers operating over arable crops and broadcast-air-assisted sprayers operating in tree and bush crops

2.3
directly sprayed area
area to which the spray treatment is intended

3 Essential elements of a trial

3.1 General

A spray drift measurement shall comprise the application of a tracer dye, or other traceable material for representing a plant-protection product formulation, to a defined, directly sprayed area of crop by means of travel in a single pass at a measured forward speed along defined tracks arranged to be at right angles to the mean wind direction. Spray drift shall be determined by sampling in a defined downwind area.

Where measurements are to be made to compare the relative drift from different application systems, then a single track may be used, arranged at right angles to the mean wind direction, with multiple passes being made on that track if necessary to obtain adequate resolution in the measurement of drift deposits. Sampling may then be within the cropped area or in a specified downwind area as above.

Where possible, all measurements shall use a tracer of low toxicity that can be safely applied to the sprayed area with no associated risks of environmental contamination. The spray liquid shall have physical properties representative of liquids typically used in the application of plant protection products. This can normally be achieved by the addition of a water-soluble surfactant at typical usage rates (for example, 0,1 %).

NOTE The formulation of some tracers can include a surfactant component.

3.2 Selection of the trial site

The trial site shall be in an exposed area with the minimum of obstructions, other than a target crop, that could influence the airflow in the region of the measurement. Details of the site and local topography shall be recorded and detailed in the report of the results of the study (see Clause 7).

The directly sprayed area shall be such that, on the downwind side, there is an area in which to position sampling stations (see 3.5). The downwind area shall be bare soil or have short vegetation (maximum height 7,5 cm) over which assessments of airborne spray drift and/or sedimenting spray drift shall be made.

The directly sprayed area shall be at least 20 m wide immediately upwind of the edge of the cropped area. Where crops are grown in rows (for example, fruit trees), then the minimum width of the sprayed area shall be as close to 20 m as possible consistent with the crop row spacing.

The length of the directly sprayed area or spray track shall be at least 50 m. When making spray drift measurements at large downwind distances from the directly sprayed area or spray track, the length of the area or track should be increased to account for the variations in wind direction. The length of the spray track shall be at least twice that of the largest downwind sampling distance and shall be symmetrical about the axis of the sampling array.

All downwind distances shall be measured from the downwind edge of the directly sprayed area (see Annex A).

A coordinate reference system shall be used to describe the layout of a spray drift trial, including location and size of spray drift collectors in sampling arrays, as described in Annex B. The details of the spray drift trial layout shall be fully reported within the results.

3.3 Conduct of trial

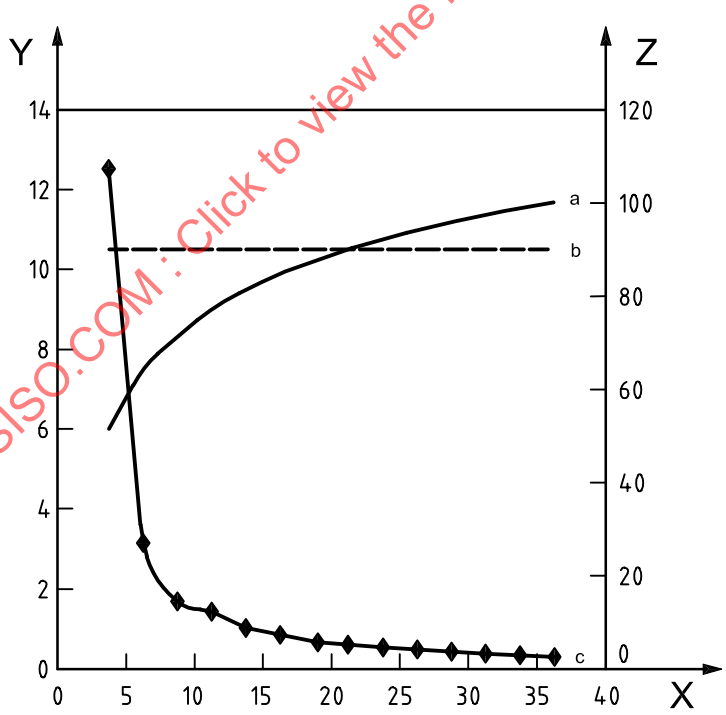
In all experiments, single-track tests should first be conducted to provide data necessary to gauge the downwind extent and decay profile of that component of spray drift originating from a single pass on the downwind side of any directly sprayed area. Comparative assessments of relative spray drift from different application systems require only single-track experiments.

In experiments to measure the spray drift loss from a directly sprayed area, subsequent multiple-track tests shall be made as needed. Adjacent swaths within a directly sprayed area should always be sprayed by moving successively in an upwind direction. The total number of adjacent swaths needed is dependent on the necessary upwind distance from which spray drift may add a significant contribution (> 10 % of total measured drift) toward the total spray drift loss from the area, and should be at least 20 m. In many situations, a default width of treated area of 20 m will be adequate. When this is not so, the distance should be calculated using the results from the single-track tests already conducted for the sprayers concerned. This calculation should use measurements from either ground and/or airborne spray drift measurements and should involve

a) the plotting of a decay curve of measured spray drift with distance from a single swath, having a scale of mean deposition from a single swath treatment in the directly sprayed area representing 100 %, and

b) a cumulative projection along the decay curve to determine the distance corresponding to a drift value of 90 % of the total amount of spray drift measured.

This distance shall then be the minimum width of the directly sprayed area (see Figure 1, which in this example gives a minimum width of around 20 m).



Key

X downwind distance (m)

Y spray drift (% of applied volume)

Z cumulative % of measured spray drift

a Cumulative % of total measured spray drift.

b 90 % of total measured spray drift.

c Measured spray drift (% of applied volume).

Figure 1 — Calculation of minimum width of directly sprayed area

Each measurement shall involve sampling ground and/or airborne spray drift downwind of the directly sprayed area (see 3.5). In addition, assessments of the spray applied to the directly sprayed area shall be made using sampling systems similar to those used for determining sedimenting spray drift (ground deposits). Care is needed to ensure that sampling media used to verify the applied dose and volume rate do not become saturated.

3.4 Use of a reference spraying system

Where comparative measurements are to be made, then measurements with a defined reference spraying system (see Annex C) shall be included in the field measurement programme. Good agricultural practice shall relate to the local conditions where the test is conducted.

3.5 Measurements of spray drift

Horizontal collection surfaces for sampling sedimenting spray drift ("drift fallout") shall be placed at a level corresponding to the top of the vegetation or crop in the sampling area and used to determine the quantity of spray liquid sedimenting in this area. Additional horizontal collectors may be placed at ground level where the crop is of irregular height or has an open structure allowing a high proportion of drift fallout to reach the ground. Horizontal collecting surfaces shall be chosen to provide good retention and recovery of the tracer used, for example, filter paper or chromatography paper appropriately supported.

At each sampling distance from the directly sprayed area, a minimum of two discrete horizontal samplers shall be used at ground level, or for a continuous sampling media, a minimum length of 0,5 m measured parallel to the spray track. Distances shall be measured to the centre of a collector surface. The minimum area of all sampling media at any one downwind distance shall be 1 000 cm^2. The minimum number and downwind positions of vertical samplers will depend on the strategy for sampling airborne spray drift (see 3.6). Measurements should be made at distances of at least 5 m and 10 m; where measurements are made beyond this, these should be at distances which are an integer multiple of 5 m.

Measurements of airborne spray drift shall be made at a minimum of one distance downwind from the edge of the directly sprayed area for reference purposes. This distance shall be

— 5 m for boom sprayers operating over field crops,

— either 5 m or 10 m for sprayers operating in bush and tree crops (including vines),

— 10 m for air assisted sprayers operating in hops.

The reference for the distance measurement is as defined in Annexes A and B. It is expected that most field trials shall involve measurements at a range of other distances.

An array of sampling collectors shall be used that enable an estimate of the airborne spray drift. The height of the array shall depend on the target crop conditions and type of sprayer being used, but shall have a minimum value of 4 m for boom sprayers operating over field crops. For air-assisted sprayers operating in bush and tree crops (including vines and hops), the height should be at least 6 m.

The position of the samples within the array should be such that the collection of more than 90 % of the airborne spray can be demonstrated by comparing the magnitudes of spray drift collected on different samplers at different positions within the array, i.e. expressing the deposit on the highest collector as a percentage of the total spray drift collected on other samplers.

A range of different types of collector or sampler may be used.

An acceptable airborne spray drift sampling system shall have

a) a defined collection area, the orientation and location of which it is possible to establish relative to the spray drift trial layout (see Annex B),

b) a high collection efficiency such that small airborne spray droplets can be collected in low wind speed conditions, and

c) a surface such that the material to be traced in the trial can be accurately and reliably recovered from this surface.

Annex D outlines considerations relevant to the selection, handling and validation of trials using tracer dyes, and lists some appropriate spray drift samplers.

The collector elements may be continuous (for example a vertical sampling line), but should be sampled discretely (for example in 1 m increments), or discrete (for example a number of separate cylinders). These shall be mounted in such a way that the support system does not prevent the effective sampling of airborne spray droplet drift. At least two separate collectors of any type in use shall be placed at each downwind distance and height where airborne spray drift is sampled to allow assessment of variability in repeated measurements. Care shall be taken when conducting trials to ensure that collecting surfaces do not become saturated and that deposits are not lost due to run-off.

If the chosen method for sampling airborne spray drift is not a cylindrical surface of diameter 2,0 mm (± 5 %), then, in addition to the chosen method for airborne spray drift collection, measurements of airborne spray drift shall also be made at the defined sampling distance using a reference spray drift collection system comprising a cylindrical surface of 2,0 mm (± 5 %) diameter with defined impaction and recovery characteristics for the material to be traced in the experiments.

The reference drift collection system for sampling airborne spray drift from boom sprayers shall be arranged to sample to a height of at least 4 m. Sampling shall be to a height of at least 6 m for air-assisted machines operating in bush and tree crops (including vines and hops). A point measurement shall be made at a height close to the centre of the spray plume.

3.6 Replication of measurements

Measurements as specified in 3.2, 3.3 and 3.5 shall be replicated at least three times in wind conditions that are as similar as is practicable. The total number of samples at each distance shall be such that a confidence interval of ± 5 % can be achieved for the mean deposit at a distance of 5 m from the edge of the directly sprayed area.

4 Measurement of meteorological conditions

Monitoring of the meteorological conditions at the time of a measurement shall be made in the centre of the drift sampling area. A mast supporting sensors shall be used to determine

— wind velocity at one height,

— temperature difference between a minimum of two heights,

— mean air temperature and wet bulb depression (or other measure of humidity), and

— wind direction with respect to the orientation of the spray track.

Measurements shall be made at a downwind distance of at least four crop heights from the downwind edge of the sprayed area where appropriate. Measurements shall be at a height 1 m above the canopy and at least 2 m above the ground and at a frequency of least 0,1 Hz sampling rate.

Meteorological measurements should be integrated values over the period of spraying for each spray drift measurement.

Any instruments used shall be calibrated prior to their use.

5 Acceptable conditions for field measurement of spray drift

Measurements shall be made in atmospheric conditions in the following ranges.

a) Wind speeds (measured 1 m above the canopy and at least at 2 m above the ground) of at least 1m/s. No more than 10 % of wind speed measurements should be less than this value.

NOTE The stipulation of a minimum wind speed is important because of the influence on drift collection efficiency and the expected variation in wind direction.

b) Wind direction: the mean wind direction shall be at 90° ± 30° to the spray track or the downwind edge of the directly sprayed area during the period of spraying and no more than 30 % of results shall be > 45° from the perpendicular of the spray track when sampling at a frequency of 1,0 Hz.

c) Temperatures of between 5 °C and 35 °C.

Because the conditions during a field measurement of spray drift are influenced by variables relating to the weather and crop that cannot be directly controlled, it is not possible to directly replicate a given measurement. For any sprayer/crop combination for which the total spray drift loss is to be quantified in order to support evaluation of environmental risk, a minimum of three measurements shall be made in crop and weather conditions that are similar.

6 Recording test conditions

6.1 Relative to spraying system

The following parameters (where applicable) shall be recorded for each test condition:

— sprayer type;

— manufacturer;

— boom size and height;

— nozzle type, operating pressure, measured flow rate and application rate in the directly sprayed area;

— fan arrangement adjustment settings and position of any guide vanes;

— position of end nozzle in relation to the edge of the directly sprayed area;

— any other relevant parameter, e.g. shielding.

6.2 Relative to crop and surface in drift sampling zone

Records shall be made of

— crop type, condition and stage of growth,

— height of crop and surface in collection area, and

— row width.

6.3 Relative to instrumentation and measurement methods used

The report of the results shall include details of the following:

— tracing system used, methods for validating sample deposit recoveries, methods of quantifying deposit degradation during handling and storage and an estimate of the accuracy and resolution of the methods used (see Annex D);

— details of the instrumentation systems used to monitor the performance of the spraying system, including pressure gauges and flow meters;

— details of the instrumentation used for monitoring the spraying conditions, including wind speed and direction, and the calibration of these instrumentation systems.

7 Presentation of results

A report of the results shall include

a) a record of machine, crop and meteorological conditions at the time of the measurement,

b) details of the trial site, directly sprayed area, local topography and sampling locations, and

c) the measured ground and airborne spray drift volumes measured at each sampling position.

Results from the repeated deposit measurements on each occasion and at each distance from the edge of the directly sprayed area shall be used to calculate a mean spray drift deposit level expressed as a percentage of the applied dose rate for horizontal sampling surfaces within the directly sprayed area.

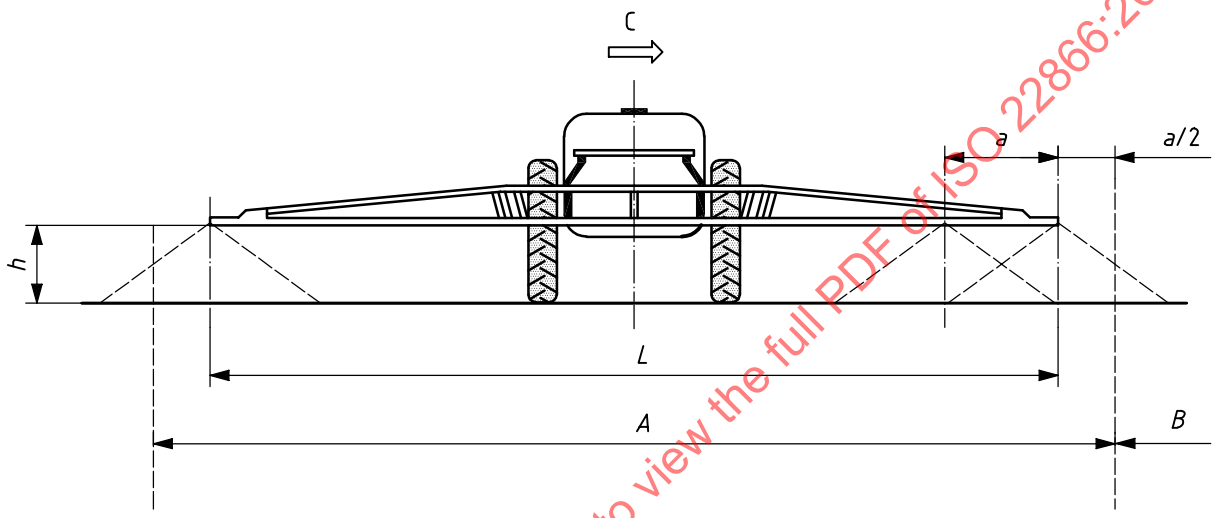
For airborne spray drift deposits, results shall be expressed as a percentage of sprayer output rate in a single pass in front of the sampling array. A measure of statistical confidence shall also be reported with the results.

An example of a tabular presentation of results is given in Annex E.

Annex A
(normative)

Definition of directly sprayed area for spray drift measurement

For boom sprayers operating in arable (field) crops, the directly sprayed area when using flat fan nozzles shall be equal to the distance between the outermost nozzles on the boom, L, plus half the average nozzle spacing of working nozzles along the boom at each end, $a/2$ (see Figure A.1).

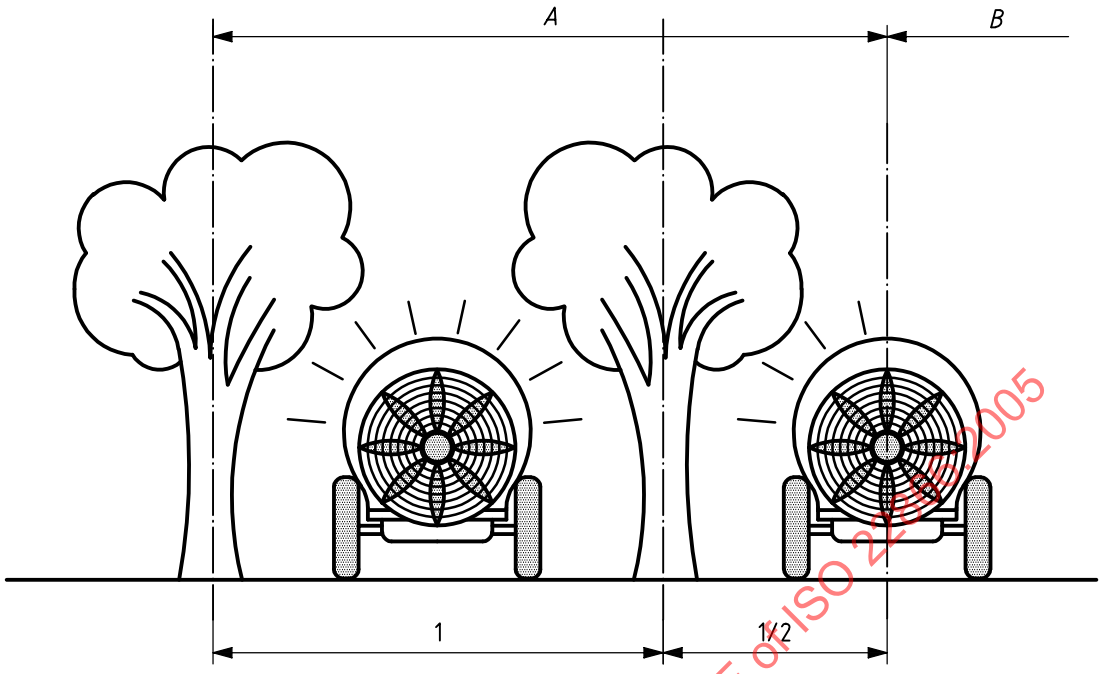


Key

A directly sprayed area ($= L + a$)
B spray drift zone
C wind direction
L boom width
a nozzle spacing
h boom height

Figure A.1 — Directly sprayed area for boom sprayer

For air-assisted sprayers operating in tree or bush crops, the directly sprayed area shall be equal to the number of crop rows sprayed (see, for example, Figure A.2), with the spray drift zone taken to be from half a row distance from the outside edge of the last row sprayed.



Key

A directly sprayed area

B spray drift zone

Figure A.2 — Directly sprayed area for air-assisted axial fan sprayer

For other sprayer types, the directly sprayed area should be as defined by the sprayer manufacturer.

Annex B
(normative)

Description of trial sites and target array for field measurement of spray drift

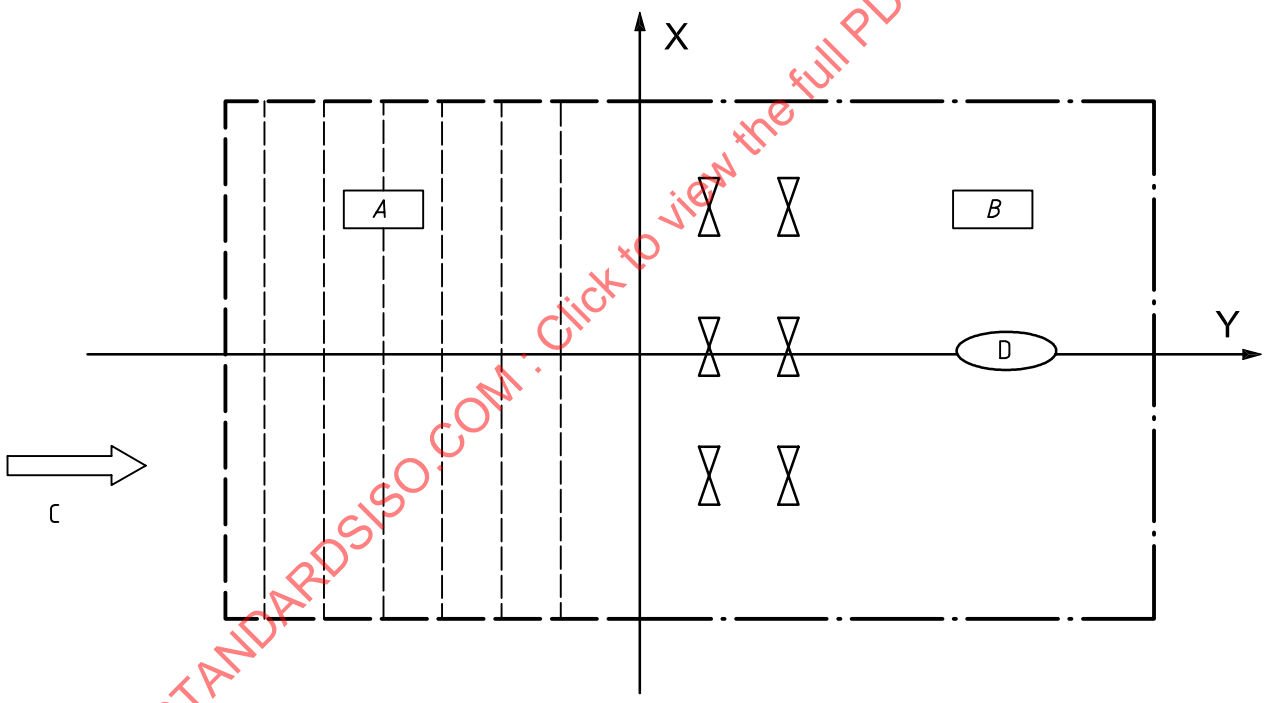
Use a three-dimensional co-ordinate system where

— X dimension is the axis in the direction of sprayer travel,

— Y dimension is the other horizontal axis 90° to X (normally wind direction),

— Z dimension is the vertical axis (90° to X and Y).

The origin for the coordinate system shall be at the mid-point of the directly sprayed area and at the furthest downwind edge of the directly sprayed area.



Key

X direction of sprayer travel
Y horizontal axis 90° to X
A directly sprayed area
B spray drift zone
C wind direction
D typical sampling positions

Figure B.1 — Diagram of layout of trial site

X dimension:

— sprayers travel from start at X = NEGATIVE;

— spray track length = maximum length in X dimension.

Y dimension:

— equals ZERO along line locating downwind side of most downwind swath (i.e. along X-axis);

— increases positively with distance downwind;

— increases negatively with distance upwind;

— swath width negative Y value, usually equals interval of consecutive upwind sprayed swaths;

— maximum positive Y value equals furthest downwind target station;

— maximum negative Y value equals upwind edge of directly sprayed area;

Z dimension:

— equals ZERO at ground surface level;

— increases with height above ground;

— decreases with height below ground.

Annex C
(informative)

Reference spraying systems for field measurement of spray drift

Where studies are to be made using a reference spraying system, this shall be reported as specified in ISO 22369.

Good agricultural practice relates to the local conditions in which the test is conducted.

Annex D
(normative)

Selection and handling of spray drift collectors and samplers

This annex gives specifications on the selection and handling of spray drift collectors and samplers.

a) The recovery and stability of the tracer on the target collector or sampler shall be verified prior to the start of any spray drift measurement. Such preliminary work shall define the level of resolution of the techniques to be employed. Details of all analytical procedures shall be documented.

b) Procedures for handling collectors or samplers prior to and post exposure to airborne spray drift shall be established that minimize any risk of cross-contamination. The potential for cross-contamination and tracer degradation shall be monitored during a trial using clean collectors or samplers and those loaded with a measured volume of the tracer solution.

c) After use, collectors or samplers should be stored for the minimum period possible. Where storage is necessary, this should be in conditions appropriate to the tracer, typically dry, in darkness, and at a temperature of less than 4 °C, with any risk of condensation minimized (since this may result in inaccuracy).

d) Deposits on collectors or samplers should be calculated based on the calibration of the tracing technique, with samples of the spray liquid taken from a nozzle at the time of the spraying.

Examples of spray drift collectors and samplers that have been used effectively are listed in Table D.1. For comparison of results the same collectors should be used.

Table D.1 — Examples of spray drift collectors and samplers

Collection surface	Characteristics	Comments
— 1,98 mm diameter polythene line — 2,00 mm diameter polytetrafluoroethylene (PTFE) line — Metal cylinders with diameters up to 5,0 mm	High collection efficiency, known sampling area	Verify tracer retention and recovery characteristics Use to sample airborne spray
— Pipe cleaners — Cotton line — Woollen line — “Pan cleaners” — Filter cloth	Very high collection efficiency, variable and unknown collection area	Determine mean sampling dimension from photographs. Used to sample airborne spray
— Filter papers — Paper surfaces — Microscope slides — Petri dishes	Low collector efficiency when sampling airborne spray	Used to quantify sedimenting drift deposits on the ground: mounted horizontally
— Active collectors such as suction samplers and “roto rods”	High collection efficiency [a]	Used to sample airborne spray only. Collection area difficult to define unless sampling is isokinetic
[a] Collection efficiency, particularly on vertical collectors and samplers, depends on both spray droplet size and wind speed.		