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Julius-Kühn-Archiv

Paolo Balsari, Hans-Joachim Wehmann

Fifth European Workshop on

Standardised Procedure for the Inspection of Sprayers in Europe - SPISE 5 -

Montpellier, France, October 15-17, 2014

Julius Kühn-Institut
Bundesforschungsinstitut für Kulturpflanzen

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Preface

Plant protection equipment must dose and distribute products exactly and function faultlessly. In order to achieve this, plant protection equipment should be inspected regularly to be able to identify and eliminate any technical defects.

However, there are three main arguments for the inspection:

- good control of the pest with the minimum possible input of crop protection product
- less potential risk of environmental contamination by crop protection products
- safety hazards for the operator

The inspection of plant protection equipment is becoming more and more interesting for the Member States (MS).

The 1st European SPISE workshop (Braunschweig, DE) took place in April 2004 in prompted by the publication of European Standard 13790; the 2nd European Workshop aims to support the MS in introducing inspections for plant protection equipment. This Workshop represented a platform on which to discuss further regulations for introducing, putting into practice and monitoring the inspections in the MS and for co-ordinating them. This was carried out in the form of lectures, working groups or excursions.

In some MS such as Belgium, Germany and the Netherlands, equipment inspections have been developed and established over the past few years, and although they are organised in different ways (state-run, private sector), they have all resulted in high-quality technical inspections, ensuring reliable and efficient plant protection equipment.

Within the 2nd SPISE workshop (Straelen, DE), the legal/statutory regulations and technical standards for successful plant protection equipment inspections already in force in the countries stated above have been presented as examples and described in detail. The excursions to the three MS have shown their practical implementation which could be analysed and taken as a basis for implementation in one's own MS.

The 3rd SPISE workshop (Brno, CZ) represented a platform on which to discuss further regulations for introducing, putting into practice and monitoring the inspections in the Member States and for co-ordinating them. In the meantime the Directive of the European Parliament and of the Council establishing a framework for Community action to achieve the sustainable use of pesticides obliges the Member States to ensure that pesticide application equipment in professional use shall be subject to inspections at regular intervals. The 3rd European Workshop informed the participants about the newest legal developments and showed which procedures/documents accompanying the article 8 of the Sustainable Use Directive (SUD) under the responsibility of the Member States are required. The Directive determines the key points. The development of procedures between the MS is left to the Member States according to the principle of subsidiarity. They have a fair amount of leeway and are able to take their own experience and conditions into consideration.

The 4th SPISE workshop took place in Lana, South Tyrol in March 2012. The aim was to support the introduction of inspections of plant protection equipment already in use in the Member States (MS) of the EU. Following the publication of Directive 2009/128/EC in October 2009, the Member States have to introduce technical inspections for plant protection equipment at regular intervals and ensure that all items of plant protection equipment have been inspected at least once by 2016. Due to the region of South Tyrol the focus this time was on the air-assisted sprayers. During the workshop the attendants were invited to register themselves in Technical Working Groups (TWGs). These 7 TWGs have the task to discuss and to prepare advices regarding up to now not clear details of article 8 of the SUD.

In October 2014 the participants of the 5th SPISE workshop met at Montpellier, France. During the 7 sessions the attendants were informed about the intermediate results of the TWGs. These groups met in the meantime three times. They presented the state of work and of the preparation of the so-called SPISE advices.

Group portrait of the SPISE 5 participants

Summary

H.-J. Wehmann

Julius Kühn-Institut, Federal Research Centre for Cultivated Plants, Messeweg 11/12, 38104 Braunschweig, Germany

The SPISE 5 Workshop took place at Montpellier, South of France, on 15 to 17 October 2014. About 100 participants from 23 European Countries and from Extra-European Countries (Brazil and Canada) took part. The locally organisation was under the responsibility of the National Research Institute of Science and Technology for Environment and Agriculture IRSTEA, Montpellier, France. The workshop site was the Agropolis conference centre which is situated in a very short distance to the IRSTEA building. The Workshop was held by the SPISE Working Group (SWG), to which representatives from Belgium, France, Italy, the Netherlands and Germany belong. For the first time Prof. P. Balsari had the chairmanship for a SPISE workshop.

The aim of the SPISE 5 Workshop was to support further the introduction of inspections of plant protection equipment already in use in the Member States (MS) of the EU. Following the publication of Directive 2009/128/EC in October 2009, the Member States have to introduce technical inspections for plant protection equipment at regular intervals and ensure that all items of plant protection equipment have been inspected at least once by 2016. The Directive determines the key points. The development of procedures between the MS is left to the Member States according to the principle of subsidiarity. They have a fair amount of leeway and are able to take their own experience and conditions into consideration.

The Workshop began with a round table session, where a representative from the Commission (K. Nienstedt) presented the opinion and expectations of DG Sanco. "Inspections of pesticide application equipment in the context of European legislation" was the title of her presentation. Further speakers reported on ISO 16122 harmonized standards (V. Polvêche, FR), "The experience of the introduction of the inspection of sprayers in use from one Member State's point of view" (A. Fjelstedt, DK), "What is the farmer's EU feeling from Copa Cogeca's standpoint" (JF. Proust, FR) and "Sprayer inspection issues – the testimony of a professional organization - Federation des Fruits et Legumes" (J.-P. Douzals, FR).

The attendance and the involvement of the representative from DG Sanco are seen as a sign of recognition for the work done by SPISE and should not go unmentioned.

The subject matter for the sessions originally resulted from the sections of Article 8 of Directive 2009/128/EC. The content of the sessions was prepared by the Technical Working Groups (TWG) which were installed at the SPISE 4 workshop at Lana in 2014.

Session 1: Inspection of new sprayers before their delivery (TWG 1)
Chairmen: E. Gil, C. Schulze-Stentrop

Session 2: Train application – State of the art and parameters to be inspected (TWG 7)
Chairmen: J. Kole, P. Balsari, H. Kramer

Session 3: Correct use of sprayer inspection harmonized test methods and definition of additional test methods for application equipment not covered by harmonized standards (TWG 3)
Chairmen: J.-P. Douzals, V. Polvêche

Session 4: "Certification" of the workshop activity (quality assurance) including test facilities (TWG 4)

Chairmen: J. Kole, P. Harašta

Session 5: Harmonise the training of the inspectors to achieve the same professional level of the inspections (TWG 5)

Chairmen: E. Nilsson, H. Kramer, H. Wehmann

Session 6: Minimum workshop facilities necessary to make an appropriate sprayer adjustment of orchard sprayer at the workshop during the inspection (TWG 6)

Chairmen: P. Balsari, J. Langenaakens, A. Herbst

Session 7: Definition of a common risk assessment procedure for Pesticide Application Equipment (PAE) to be exempted from the inspection (TWG 2)
Chairmen: B. Huyghebaert, N. Bjugstad

Nearly 40 presentations from the participants plus 12 posters showed the ongoing activities in the Member States and the current situation regarding the introduction of plant protection equipment in the MS.

During the discussions assigned to each session it was determined repeatedly that regarding several facts and circumstances there is a need for specific recommendations or advices in which way the requirements of the Directive 2009/128/EC (Sustainable Use Directive) should be implemented and applied. Against this background it was decided to prepare "SPISE Advices" to each of these issues.

On the second day an excursion was following. The first highlight were the widespread visit to the testing facilities of IRSTEA and the demonstration of inspections of sprayers plus the testimony of an inspector by GIP Pulvés. The program was topped off with the demonstration of the "Ecospray Viti test bench" where different application qualities for wine-growing were demonstrated. The next item on the programme was the visit of the winery of the Domaine du Chapitre, Villeneuve les Maguelonne. Here the participants were informed concerning the special requirements on the vine-growing in that region. And finally during the visit of the Experimental station for horticulture (CEHM) at Marsillargues the participants were able to gather information on the wide range of application technology in fruit-growing and horticulture plus their inspection. An exhibition of orchard sprayers and of test equipment for the measurement of the vertical spray distribution offered extended information. The special circumstances in the surrounding of the Montpellier region requires a comprehensive control of mosquitoes. The different equipment used for this purpose plus their inspection possibilities were demonstrated and explained by the representative of the "Interdepartmental Agreement for mosquito control of the Mediterranean coast (EID)".

Information portal: http://spise.jki.bund.de

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- National Research Institute of Science and Technology for Environment and Agriculture IRSTEA, Montpellier, France
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for the excellent hospitality and fruitful co-organization,

Furthermore we would like to thank

- the Domaine du Chapitre, Villeneuve les Maguelonne,
- the Centre Expérimental Horticulture de Marsillargues,
- the Entente Interdépartementale de Démoustication Méditerrannée

for the very well organized visits.

Introduction to the Workshop

P. Balsari

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Some time has passed since the SPISE 1 Workshop at Braunschweig 2004 and since then a lot has happened and many things have been clarified. Today we already meet for the SPISE 5 workshop and I can welcome more than 100 participants from 23 European countries and 2 extra European countries (Brazil and Canada).

This fig. shows the colleagues from the Spise Working Group (SWG), coming from Belgium, Germany, France, the Netherlands and Italy.

Fig. 1 Members of the SPISE Working Group

First of all I would like to underline the two main objectives of SPISE:

- Harmonisation of procedures for the inspections of sprayers in use in the European Union
- Support to the implementation of the Directive 2009/128/EU on sustainable use of pesticides regarding the prescriptions dealing with sprayers inspections in EU Member States.

It is the first SPISE Workshop after the official adoption by Member States of the Directive 2009/128/EU. The main objectives of the present Workshop shall be:

- Update the present situation of sprayers inspection in the Member States. Support homogeneous sprayer inspection activities in EU Member States so to get mutual recognition.
- Improve communication about sprayer inspections (involvement of farmers through COPACOGECA).
  Contribute to overcome operative difficulties through the activities of SPISE Technical Working Groups (TWG).

For this last mentioned objective please let me come back to the SPISE 4 workshop held in 2012at Lana (South Tyrol). One of the outcomes of that workshop was the establishment of the Technical Working Groups with the following tasks:

1. Develop a common proposal concerning how to deal with **minor defects.**
2. Develop a common proposal concerning how to deal with **brand new sprayers**.
3. Define a common **risk assessment** procedure for PAE to be exempted from the inspections.
4. Define a common way on how **to "certificate" the workshop activity** (quality assurance), including the test facilities.
5. Define guidelines on how to make **sprayer adjustment** (both field crop and orchard sprayers).
6. Collect from MS available **training material** and make it downloadable on SWG website.
7. Create a **SPISE database** with all MS authorized inspectors and workshops.
8. Define SPISE guidelines for the inspection of **railway train sprayers**.

All participants of the SPISE 4 workshop were invited to contribute in one or more working groups and to sign in the displayed lists. About 30 people followed that invitation and in the meantime the Technical Working Groups met already three times. In 2013 the members met at Braunschweig and at Barcelona. In 2014 the members were invited to Amsterdam. In very intensive and constructive manner the TWG-members brought fourth still open topics. Today the TWG will present the results of their work. Therefore the agenda of this workshop corresponds to the topics processed by the TWG members.

Before starting the main part of the workshop please let us all together recall Mr. Per Gummer Andersen. He passed away at the 31st July 2014. For several decades he left an imprint worldwide on the application technique area. From the beginning he also supported the SPISE community by preparing, organizing and chairing workshop sessions. Also the definition of the objectives of the SPISE TWG were fundamental provided by Per.

Now Eskil Nilsson and Emilio Gil will give a video presentation concerning the life's work of Per Gummer Andersen.

Per Gummer Andersen
2.1.1949 - 31.7.2014

Inspections of pesticide application equipment: Provisions and current implementation under the Directive on sustainable use of pesticides and other European legislation

K. Nienstedt

DG Sanco - Unit E3: Chemicals, Contaminants and Pesticides,
European Commission, Brussels, BELGIUM

DOI 10.5073/jka.2015.449.0001

An overview of the European legislation related to inspections of pesticide application equipment will be given, in particular regarding Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use of pesticides and the progress of the legislative process for the adoption of the Regulation proposal on official controls (COM (2013) 265 final). Updated information is available via **http://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/index_en.htm**

ISO 16122 : A harmonized standard for the inspection of sprayers in use

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DOI 10.5073/jka.2015.449.0002

After publishing the Directive for a sustainable use of pesticide, the European Commission asked to the CEN (European Committee for Standardization) for a revision of the standard 13790. The Directive describes some essential requirements which have to been translated into technical words and specifications.

In accordance with the Vienna agreement, ISO (International Standardization Organization) has been associated, in order to produce reference documents applicable in every country, even if not concerned by the European rules.

In parallel, it was necessary to deal with new sprayers in order to coordinate the requirements applicable on new / in used sprayers and make them consistent.

This work started in 2010. Then start a long procedure to elaborate proposals, acceptable by everyone. This new text should conciliate:

- The minimal requirements needed by the directive
- The requirements applicable on new sprayers
- The existing rules available in countries concerned by a mandatory inspection of sprayers

The feedback of more than 15 years' experience in some countries

Three international meetings, five drafts, two general votes, and more than 900 comments were needed in order to establish a final draft! It has been submitted to a vote during summer, agreed by more than 85% of the members.

The benefits of such standards are obvious, not only for complying the Directive requirements, but also for a minimal performance of sprayers and prevent serious defaults, and for a mutual recognition of inspections made all over Europe.

The experience of the introduction of the inspection of sprayers in use from one Member State's point of view

A. Fjelstedt

Danish Environmental Protection Agency, Ministry of the Environment, Denmark

DOI 10.5073/jka.2015.449.0003

The requirement in the EU directive 2009/128/EC regarding inspection of sprayers resulted in a need for a national set up of such a system in Denmark, since we did not previously have such a requirement for sprayers in Denmark. We went through the following process during the last few years:

- We got inspiration from the inspection-systems already established in other countries e.g. in the Netherlands and Sweden.
- We decided on the overall structure of the inspection system and made national regulation:
    - Establishment of a three year phase-in period for having all pesticide application equipment inspected not later than November 2016.
    - An authorization process for inspection companies
    - An education process for the inspectors
    - A process for the control of the inspection companies
  - We established an expert group consisting of various types of experts on the field:
    - We produced a guideline that in detail explains the national regulation and that in detail describes how the inspection should be carried out. This was based on the standards.
    - We developed inspection reports for the inspection
  - We launched an application process for companies that would like to become authorized as inspection companies and we established an education for inspectors (4 days with test)
  - We made a contract with a company that will carry out control of and give guidance to the inspection companies.
  - We had an IT system developed to be used by inspectors, the Danish EPA and the control company.
  - We developed a sticker system for the inspected sprayers and a system for paying fees to the Danish EPA for those stickers in order to have all our expenses covered.

At present our main problems are the following:

- Farmers hesitate to have their sprayers inspected
- Many authorized inspection companies with educated staff and with all equipment in house still hesitate carrying out inspection of sprayers.
- It will be difficult to check if all sprayers in use have been inspected before November 2016
- We find it difficult to develop risk assessments to decide on different timelines for inspection for different types of sprayers.

We find it difficult to be ready with inspection systems for all kinds of sprayers in time to be able to meet the deadline November 2016 – e.g. due to lack of standards for inspection of certain types of sprayers.

Session 1: Inspection at regular intervals – Inspection of new equipment (TWG 1)

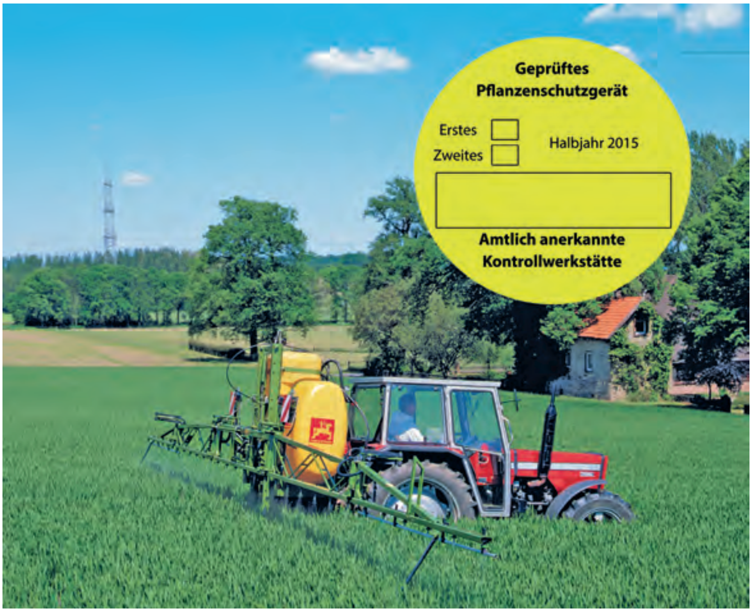
Inspection of brand new sprayer by a sprayer manufacturer and problems encountered

T. Kovermann

Amazonen Werke H. Dreyer GmbH & Co.KG
DOI 10.5073/jka.2015.449.0004

Following the amendment 2009/127/EG to the Machinery Directive 2006/42/EG, all new manufactured sprayers in the European Union are self-certified by the producer. This means from the 15.12.2011 new sprayers in the EU are not longer subject to any approval procedure by an inspection authority. The producers are engaged to certify their plant protection machinery through the CE marking and a declaration of conformity by themselves. This ensures that every delivered machinery in the EU fulfills the requirements of new plant protection machinery in the market by 2006/42/EG and 2009/127/EG. This self-certification relieves the declaration procedure by third party authorities and is controlled through the market surveillance in the countries. The BBA (later JKI) declaration procedure in Germany was a successful system to bring a technical standard to new machinery in the market. From July 1988, every different component of new machines in Germany had to be declared by the manufacturer. This declaration contained for example tanks, armature, spray boom, pumps, etc. Every addition or change in the design had to be updated in the declaration. From the perspective of a manufacturer there is no significant change due to the self-declaration in internal processes. The producer is responsible with a legally binding signed certification for the technical standard of new machinery. In the past it was done by the BBA declaration and is today verified by the CE marking which confirms EN ISO 16119. The CE marking is significant for the complete European Union and therefore no specific machine configuration has to be declared anymore.

Amazone Product Certification including EN ISO 16119 and EN ISO 4254



Inspection of used sprayers in Germany since 01.07.1993

In addition to the manufacturer declaration that all technical components on the new machine fulfill the requirements of EN ISO 16119, used sprayers have to be inspected periodical by the specifications of EN ISO 16122 regarding 2009/128/EG. The initiation for a periodical inspection for used sprayers started in Germany in July 1993. With the beginning of the mandatory inspection of used sprayers, customers demanded complete tested new machines directly from factory. So they are assured to get a "Ready-to-use" machine directly from factory and have no additional efforts before the first use. Many manufactures offer this first control from factory together with the delivery of the new sprayer.

All these directives on the European Union level are to harmonize the standards transnational and each Member State is required to implement them into national regulations. The current situation reveals a still not consistent implementation of the changes in European directives to national laws. The international orientation in many cases to the BBA (JKI) declaration procedure does not exist furthermore. The implementation of actual directives and also the control if the included demands a fulfilled is often insufficient. This causes disordered processes in the handling with new machinery for manufactures, national distribution partners and furthermore for the customers.

Inspection of cross distribution on test bench according EN ISO 16122

Quality control of each machine in production

Independently from the demands of EN ISO 16119 is the continuous quality control with a final test of each sprayer a standard procedure for a reliable product. The Amazonen Werke quality control exemplary includes the test of incoming parts and internal manufactured components. Continues controls during the assembling and regular machinery-audits ensure a constantly high and transparent quality standard. Independently from an optional inspection according to EN ISO 16122, every machine gets a final quality test with a test run under pressure with water. A detailed control of the functionality and reached parameters of all components, the right calibration of the complete system and the expertise of optical details and appearance ensures that each delivered machine works proper and sustainable from the first use over long time.

Conformity of Production Processes of Field Sprayers

P. Hloben

Deere & Co.
DOI 10.5073/jka.2015.449.0005

Introduction

Conformity of Production (CoP) is a means of evidencing the ability to produce a series of products that exactly match the specification, performance and marking requirements outlined in the in the technical construction files, or type approval.

The sprayer manufactures are using industrial standards, conducting risk assessments, internal and third-party testing to ensure they meet CE mark self-certification requirements given by the Machinery Directive 2006/42/EC for the machinery use for pesticide application. The results from these activities are documented in the technical construction files for each product/model which are available for the market surveillance and other control authorities.

The sprayer producers also must demonstrate that their manufacturing organization (facilities) have fully functioning manufacturing quality control systems (incl. quality audits, certification of incoming components, run-off specifications, etc.) that assure products are compliant.

To help SPISE community to build up a correct picture of the sprayer industry and increase the trust in the self-certification of field sprayers we want to share some information about quality control systems and methods which sprayer manufacturers are using to control their products.

Requirements and Responsibilities of the Manufacturers

There are certain obligations which implies to every sprayer manufacturer. The most important one is the self-certification according to the Machinery Directive, which is usually based on fulfilling the requirements of EN ISO 16119. The self-certification is part of the declaration of conformity and is shown on the machine by the CE mark.

This certification is usually related to the type of equipment; due to the required measures for ensuring the quality, the Declaration of Conformity states the conformity of each individual machine. The self-certification is the formal and legal statement addressed to authorities that the machine complies with the Machinery Directive.

By the inclusion of the sprayers into Annex 1 (not Annex 4) EC has rightly concluded that mandatory third party inspection was not part of the compliance requirements for sprayers.

Related to the Conformity of Production there are following paragraphs specified in the Machinery Directive 2006/42/EC:

Article 12 **- Procedures for assessing the conformity of machinery**

Sub §2.: Where the machinery is not referred to in Annex IV, the manufacturer or his authorized representative shall apply the procedure for assessment of conformity with **internal checks on the manufacture** of machinery provided for in Annex VIII.

Annex VIII - Assessment of conformity with internal checks on the manufacture of machinery

Sub §3.: The manufacturer must take all measures necessary in order that the ***manufacturing process*** *ensures compliance of the manufactured machinery with the technical file referred to in Annex VII, part A, and with the requirements of this Directive*

Annex VII A 1 (b)

A. **Technical file for machinery**

…The technical file must demonstrate that the machinery complies with the requirements of this Directive. It must cover the design, **manufacture** and operation of the machinery…

1. The technical file shall comprise the following:

(b) for series manufacture, the internal measures that will be implemented to ensure that the machinery remains in conformity with the provisions of this Directive.

The internal measures, mentioned in Annex VII A 1b, may include the monitoring of supplies of materials, components and sub-systems.

Next, it may includes the inspections and tests to be carried out at various stages of production and on finished products, but also measures to ensure that the manufacturer's specifications are correctly executed by subcontractors.

These measures can be implemented by applying quality management systems.

Conformity of Production (CoP)

The Conformity of Production CoP is a means of evidencing the ability to produce a series of products that exactly match the specification, performance and marking requirements outlined in the in the technical construction files, or type approval.

The CoP is a part of the complete Quality Management System which shall be integrated into each department of the production organization which needs to demonstrate its ability to consistently provide product that meets the customer requirements, applicable statutory and regulatory requirements.

The Quality Management System is normally documented by a Quality Manual which describes the processes, procedures, control plans and working documents used in the organization. (For example as a process can be seen the Compliance Audit process which defines the information and material flows, departments' responsibilities and what are the appropriate actions when an audited machine will not pass the criteria set up by the product specification).

The Quality Management System is not new for many of sprayer manufacturers and its principles and requirements are specified by several standards:

- ISO 9004:2009 - Guidance to organizations to support the achievement of sustained success by a quality management approach
- ISO 14001:2004 - Environmental Management System
- OHSAS 18001- Safety Management System
- ISO 19011:2011- Guidelines for Auditing Management Systems
- ISO 9001:2008- Quality Management Systems

The last mentioned is a popular Quality Standard which specifies a quality management system, but it is not a mandatory requirement to obtain CoP clearance. An internal quality management system can ensure CoP clearance too.

Production Quality Control Measures

The following production quality control measures are the typical outcome from a sprayer manufacturer which has to ensure that his products meet the regulatory requirements specified in the Machinery Directive 2006/42/EC (Annex VII A1b):

- Goods Receiving Inspection
- Production Quality Warrant
- Production Part Approval Process (+ Control plan)
- Quality center verifications
- Serial number registration
- Run- Off specification
- Pre-delivery Instructions
- Product Audit
- Tooling Calibration

The first four measures, mentioned above, describe the controlling of single components which are critical to quality, the machine assembly, testing and delivery of the machine to the customer. These measures will be described more in details.

Good receiving inspections and other actions taken at supplier's level

Many organizations have a program to designate "certified suppliers". They receive products from these suppliers directly into stock. If they qualify suppliers by auditing their quality system, by inspecting trial orders, or by other means they can determine what kind of sampling plan they need to monitor the quality of their product. (E.g. there can be requested 100 % checks and calibration of the digital pressure sensors at the supplier location, before their delivery. It includes also decisions about the proper packaging of the component with an aim to avoid their damage during the transport from the supplier to the production line)

Some products come with certain certifications or standards already met for the product. These come with a Certificate of Analysis or other evidence that control is exercised at the supplier's location. If this is the case, the inspection may be checking for a Certificate.

Incoming inspection can be as simple as reviewing the packing slips and verifying that the correct item and quantity are received. It is up to the organizations to determine how the quality of the supplies affects their product quality and how you will measure and monitor.

An inspection can be performed on shipments of goods arriving at a manufacturer's location it may include: functionality testing, drawing check (+ measurements), material analysis and surface inspection of shipping containers.

Fig. 1. Example of component which are certified by suppliers (Quality checks are done at supplier facility)

Production Quality Warrant

The quality warrant composes from the production part approval process (PPAP), control plan, serial number registration, run-off specification and quality notes.

The PPAP is a process which is used mostly in the road and off-road vehicle supply chain for establishing confidence in component suppliers and their production processes, by means of demonstrating that supplier can meet the manufacturability and quality requirements of the supplied parts to the customer.

It must be ensured that the customer engineering design record and specification requirements are clearly understood and fulfilled by the supplier. Next, it has to demonstrate that the established manufacturing process has the potential to produce the part that consistently meets the all requirements during the actual production run at the quoted production rate.

There should be the defined who is the process owner, how is the process documented, monitored, analyzed and improved. The records shall be maintained.

The control plan describes the ongoing tests conducted throughout the production process and their frequency. The plan is set up for an individual component or a machine function, if it is defined by PPAP and by the quality part level (QPL) which is specified during the design process. The QPL is based mostly on the complexity of the part or its impact on the final function of the machine. (E.g. a simple screw can be rated as QPL =1, a control unit QPL=4).

The control plan includes also the frequency of the checks. For example for the nozzle manufacturing includes the control plan the frequency of the test bench testing of the nozzle batches, the time of the testing am/pm for the 24/7 production process, a plan for machine and tooling calibration, etc..).

Serial number registration is used for some critical pats for the tracking purposes (engine, axles, braking systems, pumps, etc…)

Run–Off Specification defines the machine run off requirements for each model/version of the sprayer manufactured by the production facility. It is applicable to each single sprayer produced. The run-off specification includes for example directions for programming, factory adjustments, checking various systems for appropriate function, adding the appropriate fluids to the machine and the general machine auditing.

4.3.4 Validation dead band setting

To ensure the regulation is working as expected later in the field, it is essential that the regulation dead band in the factory settings is set correct as long as EOL programming is not implemented.
Check in "Factory Settings", Tab "Regulation 3":
R900: Reg. Dead Band set to 1.5
M900(i): Reg. Dead Band set to 3

4.3.5 Flushing of the spray-lines

Close all sections (also Master will be off).
Ensure no end stops are mounted on the spray lines so water can flush through.
Open 1 section and flush it with 9 bar on the spray line for 10 seconds.
Close section and flush next section.
Continue until all sections are flushed.

4.3.6 Calibration of Flow Sensor (<KC>)

Go to Machine Settings, Calibrations and select "flow". Then press "AUTO"
Follow the instructions on the display.
Alternative calibrations are allowed using the pattemator to determine the correct value.
Value shall be between 140 and 170 pulses/ltr.

4.3.7 Calibration of the Liquid Pressure sensor (<KC>)

Connect a pressure gauge (electronic or mechanic) to the spray line, in the middle of the spray boom.
Go to Machine Settings, Calibrations and select " Liquid Pressure".
Follow the instructions on the display.
The pressure to use for calibration is the value as indicated byte connected pressure gauge.
Zero calibration shall be between 0 and 20 ADC
With reference pressure of 5 bar on the spray line, sensor ADC value shall be between 180 and 230 ADC.

4.3.8 Nozzle calibration

Calibrate each nozzle by collecting the amount sprayed out for 1 minute when the reference pressure as set in the nozzle presets is applied to the sprayline
Measure 1 nozzle on each section.
Go to Machine settings, Boom, Nozzle Presets to see the value for the specific nozzle.
Determine the average volume for 1 minute and enter it into the display.
Repeat for each nozzle present on the machine.

4.3.9 Membrane check

Open all sections.
Have the machine spray with 6 bar when using non-fertilizer nozzles. Spray with 3 bar when using fertilizer nozzles.
Close the master.
Close the section valves one by one.

SIZE	CAGE CODE	PART NUMBER		VERSION	REV
A4		WZW13972		JD90	E
SCALE NONE		METRIC	⊕⊲	SHEET 38 of 45	

Fig. 2. Example of the Run-off specification for field sprayers used at final test area.

Pre Delivery Instruction

To meet the requirements for the conformity of production does not apply only to the quality checks at manufacturing location, but also at the dealer's location after delivery from the factory and just before delivery to customer. In the Fig. 3, are shown examples of the pre-delivery instructions for a self-propelled sprayer.

Predelivery

After the machine has been assembled, inspect to be sure that it is in good running order before delivering to the customer. The following checklist is a reminder of points to inspect. Check off each item as it is found satisfactory or after proper adjustment is made.

- ☐ Check pump oil level.
- ☐ Verify all moving parts move freely.
- ☐ Check machine for damage (electrical wiring, hoses, and decals).
- ☐ Check functions are all operating properly.
- ☐ Check nozzle output.
- ☐ Check spray pattern of nozzles.
- ☐ Check operation of lights.
- ☐ SMV emblem and reflectors installed.
- ☐ All fluid levels have been checked. All grease fittings have been lubricated.
- ☐ Tires and suspension are properly inflated. Tighten wheel nuts to specified torque.
- ☐ Solution system operates properly and does not leak.
- ☐ Hydraulic systems operate properly and do not leak.
- ☐ Verify that nozzles are drip free.
- ☐ Check brakes for proper operation.
- ☐ Check boom transport supports have been correctly adjusted.
- ☐ Verify that antifreeze has been removed, and all dismounted parts have been refitted (filters, hoses, pressure gauge, and end caps).
- ☐ Verify all the customer-ordered attachments have been installed.
- ☐ Verify that spraying control unit has been programmed and the sensors have been calibrated.
- ☐ Check any parts scratched in shipment have been touched up with paint.
- ☐ Factory made entries in GreenStar™ 3 2630 display monitor have been confirmed and/or reset to agree with calibration values.
- ☐ Test machine with clean water.
- ☐ This machine has been thoroughly checked and to the best of my knowledge is ready for delivery to the customer.

Signed: ______________________

Date: ______________________

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Agitation Check

1. Push agitation switch (A) to the ON position.
2. Check double agitation nozzle (B) and the single agitation nozzles (C) are all flowing water inside the tank.
3. Push agitation switch to the OFF position.

A—Agitation Switch
B—Double Agitation Nozzle
C—Single Agitation Nozzles

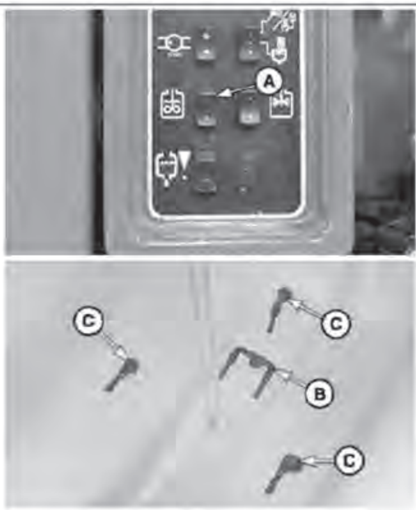

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Fig. 3. Example – Pre-delivery Instruction.

Conclusion

The Machinery Directive requests to implement internal measures to ensure that the machinery remains in conformity with the provisions of this Directive (CoP) and document these in the Technical Construction File. The Conformity of Production is mandatory for every manufacturer (large or small) who places CE mark on its sprayer.

There are different ways and provisions how to ensure the CoP during the whole production process. Each manufacturer can decide how will he establish the quality controls thorough the manufacturing process or at the end using e.g. final test area or dealers location equipped with proper instrumentation.

Some companies have already established Quality Management System which ensures the CoP and some are still developing it. However, there are some manufacturers which will be not able to reach the required level of quality it and will still place the CE mark on their non-compliance products. For this cases there shall be an appropriate action taken by the market surveillance authority.

The sprayers are included into Annex 1 of Machinery Directive which means that mandatory third party inspection, as the one used for the sprayers in use (specified in ENISO 16122) is not a part of the compliance requirements and it can be used only optionally.

Inspection of New Sprayers before their Delivery - The position of CEMA

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HARDI International
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In the harmonisation process it is important to reach a point of common understanding and acceptation among different stakeholder. In the sprayer inspection process it is important to get an overall European wide level which allows manufactures of spraying equipment to deliver products direct to the end users without specific local testing. The CEMA members define their position by clarifying what is done anyhow in the production process.

CEMA as THE EUROPEAN AGRICULTURAL MACHINERY INDUSTRY

The development and production of agricultural machinery is among the most dynamic and innovative industry sectors in Europe. Over 50 years CEMA has been providing an interactive platform to manufacturers of agricultural machinery to formulate common industry positions and work towards a higher degree of European harmonization in the sector. In CEMA are approx. 4500 manufacturers of agricultural equipment consisting of large multinational companies as well as numerous small and medium-sized enterprises. CEMA members produce more than 90 % of the new sprayers in EU.

Cooperation between CEMA and SPISE

CEMA supports the current practice for the standardized inspection of sprayers in use according to the requirements of EN ISO 16122, overseen by Member State authorities and undertaken by certified testers.

CEMA members work active in the SPISE community. It is not only considered the original performance of the spraying equipment, we also support its use, care and maintenance. Also the daily contact to the dealer network is an important issue, as farm machinery dealers are offering the test to the end-users in most member states today.

It is important to have clear definitions to clarify the difference between in-factory testing and the In-factory inspection.

In-factory testing

- Quality, performance, compliance related tests, checks and controls conducted during the whole production process (incl. final test) to ensure the requirements given by Machinery Directive (EN ISO 16119)
- Organized by quality management & manufacturing
- Defined by production engineering and compliance

In-factory inspection

- Inspection of finalized sprayer according EN ISO 16122
- Certified personal
- Certified measurement tools
- Decal is placed on sprayer
- Test report is accompany the sprayer and copy is filed

New sprayers have to fulfill EN ISO 16119 (2006/42/EC). The EN ISO 16119 ensures a higher level of performance than required by sprayer testing standard EN ISO 16122. In the production process are already in-factory tests done. It must be cleared as well that the self-certification process including the Declaration of Conformity which has to be provided with the machine is not a type approval, but it means that the sprayer delivered complies with the Machinery Directive 2006/42/EC.

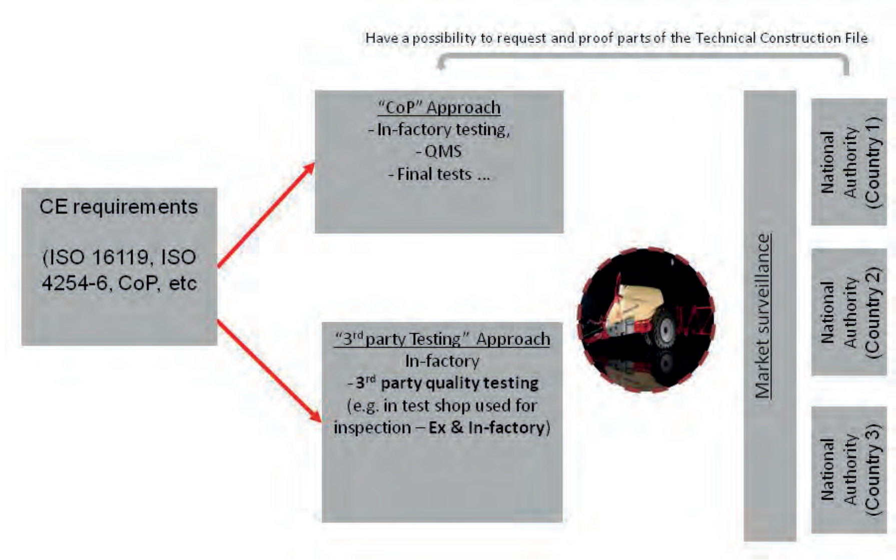
Sprayers in use test – EN ISO 16122

The In-factory inspection_is not new in the past SPISE workshops have been several examples presented, there had been also visits to manufactures, showing the inspection process. Some manufacturers have their factory approved by D, NL authorities and do in-factory inspection of sprayers; this process is running since more than 20 years. There is a long time experience with the test of new sprayers, which is sometimes a reduced test. Somehow is this situation history, as we have now the amendment of the Machinery Directive (MD) and Sustainable Use Directive (SUD) in force which means a self-certification process which forced the manufacturers to do a big work to run this process. Today we have far more environmental requirements for new sprayers, which are more demanding than those of the inspection of sprayers in use.

A comparison of the testing requirements of EN ISO 16122 and requirements for new sprayers to meet EN ISO 16119 can be done step by step to find an agreement if the conformity of production (CoP) is dealing with the EN ISO 16119 standard. This table gives a few examples how a list from a manufacturer could look.

Requirements of EN ISO 16122-2	Visual check / Function test	Measurement	Factory Testing to meet CoP (EN ISO 16119)
Static leaks	x		During the tank sensor calibration. During the Pressure regulator set up.
Pump capacity		x	New pump (not wear out) - supplier quality declaration, check quality statistics from supplier. Or internal check with flow meter - selectively every X machine from Y, if internally produced pumps - Provide information from pump supplier. - Ensure correct pump / machine configuration. (BOM list) Pump capacity on the type plate.
Nozzle spacing/orientation	x	x	Drill fixtures (Quality control), Final test area measurement, visual check, or Patternator test
Pressure drop		x	Per design, - provide Technical Construction File results discuss if measurement is needed.
....	....	....	....

There shall be an insurance the same level of quality can be reached in this process. And the CE mark shall be seen as an indication of this. Of course there is control by the market surveillance in the different member states.



The CEMA proposal

The CEMA makes a proposal how the EN ISO 16122 inspection scheme could be used to have procedure how to do inspection of new sprayers. Manufacturers will provide a 'Certificate of Inspection' (CoI) identifying the conformity with EN ISO 16122 for the serial number machine with which the CoI is being shipped. The customer could use this certificate to obtain the appropriate certification label by the local authority for the purpose of certifying the machine to the appropriate sections of Directive 2009/128/EC. (This will allow keeping the national registers). The Technical Construction File (TCF) based on the application of Machinery Directive (2006/42/EC) and the European Directive (2009/127/EC), which is done by the manufacturer during the design and manufacturing process indicates that the sprayer complies with EN ISO 16122.

Another option is an In-factory Inspection as it has been done in some member states since a long time. Because there is a certain market demand for users to have new sprayers certified as complying with the requirements of EN ISO 16122 e.g. to comply with crop assurance schemes or food supply chains. Also in the case of "3rd party testing" approach for new sprayers, some manufacturers would like to continue to offer "in-factory inspection" to fulfil CE requirements (no decal). The In-factory inspection is not applicable at the whole scale of the EU market if there is no common and harmonized process. It would be very difficult for manufacturers, if we have to get approved by all member states. Including documentation of stickers and test certificates in 30 different versions! CEMA feels that this would not be in line with the idea of free trade inside the EU. A new approach for a simplified process is needed.

Harmonized procedures

CEMA would like to have a clearly defined harmonized test procedure across all EU member states - based on the requirements on EN ISO 16119 which also fulfils the EN ISO 16122. There should be one simple format of the test report which can be mutually recognized by all Member States. A Certificate of Inspection (CoI) would help to get a more harmonized procedure to bring sprayers into different Member States. Further there is a need of a local transfer procedure – registration demands have to be organized. There is also the difficulty with different time interval before the first mandatory inspection, after the first use. This leads to difficulties in understanding the procedure and the quality of delivered sprayers. The time period should comply with the current European legislation (Sustainable use of pesticides (SUD) – 2009/128/EC)

Mutual Recognition

The harmonization of the testing procedure and intervals are essential pre-requisites for the mutual recognition of the test reports and certificates / stickers between Member States. Mutual recognition and general harmonization will make the whole testing and inspection framework clearer and more understandable for all stakeholders (authorities, testers, manufacturers, dealers and farmers). An acceptance of a certificate/sticker which has been obtained in another Member State than the country where the sprayer is finally used is demanded, manufacturers would like to work only with one certificate/sticker. As a registration of sprayers is demanded in some countries a system must be developed so the end-user / farmer get his local approval. This shall be the task for the end-user.

Challenges – jobs to do – conclusions

CEMA would like to implement a Certificate of Inspection, but also other options as in-factory inspection must be still possible, so also smaller producers and self-made sprayers could still be inspected. A harmonized certification document / sticker as a type of test report for new sprayers must be developed here SPISE is needed to coordinate this process to reach a maximum of acceptance.

A mutual recognition document is need, but who can do this? As there is no official mandate!

National agreements regarding – factory certification are needed as this seems to be the only way to get progress. Also the question how does the farmer / machine owner gets a local certification if needed and how the sprayer will be registered in different national schemes? Here the farmer association needs to be involved – approach the end-user needs a machine which is proofed and fulfilling EN ISO 16119 and EN ISO 16122 – this is needed to fulfil cross compliance and different certification schemes - this cost money!

There are also challenges in the communication to the market, how can common understandings of the procedure be reached. In the optimum case all Member States would be involved and accept the system.

We need SPISE as a platform to move forward on these issues!

Session 2 : Train application – State of the art and parameters to be inspected (TWG 7)

Testing of weed seeking systems for spray trains - development of a test procedure

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Introduction

G&G is a Hungarian company working as a service provider within the field of vegetation control on railroad tracks. Due to the fact that organic matters can reduce the necessary elasticity of the track installation, weed control is an important issue for the safety of railroad traffic in general. For this reason weed growth in the roadbed and alongside has to be controlled continuously, whereat due to the total size of the railroad network the application of herbicides is the only procedure being economically in our days. From an environmental and also economical point of view the spraying should only take place if weeds really exist within the target area. If not, spraying should be interrupted in order to avoid the disposal of herbicides and to safe them. For this reason G&G has developed a precision spraying system for weed control on railroad tracks, consisting of weed detection and mapping unit as well as a controllable spraying device being able to apply herbicides on nine different segments separately within the target area (Fig. 1).

Therefore a project has been initiated with the aim to establish methodologies to determine the quality of the weed detection and mapping system as well as the quality of the precision spraying device related to the target area. The objectives of the project was to determine the

- sensitivity and accuracy of the weed detection system with different speeds of the spray train,
- influence of different lighting conditions on the detection system,
- longitudinal distribution of the application system,
- lateral distribution of the application system and the
- switching delay of the application system.

To figure this out empirical experiments on a test track were done using pieces of artificial turf of different sizes for the measurement of different parameters being able to characterize the accuracy of the application.

Fig. 1. Spray train spraying the side of the railroad track. The weed detection unit is in front of the locomotive (between the headlamps) (Phot. G&G).

Material and Methods

The tests were done on a railroad track in Deszk (Hungary). In preparation of the tests the whole test site was treated with a total herbicide on a length of two kilometers weeks before in order to destroy all green plants which could influence the experiments. Within the test site three test tracks with a total length of 150m each were calibrated and marked in five meter steps with paint.

The spray train has a total working width of 8.06m and is equipped with a multitude of nozzles on a support frame beneath the wagon (Fig. 2). The application of herbicides can be done in nine different sectors parallel to each other but also independently from each other. The onboard operating unit gets the information which nozzle has to be opened or closed from a sensor system located in front of the train (cf. Fig. 1). This system is able to detect different shades of "green" within the target area. From this information a weed map is compiled and used as a basis for the control of the herbicide application (Fig. 3). The system also compiles an additional map showing all areas where an application of herbicides had been done. Together with the GPS-data these maps are also used for reasons of documentation. The spray train is equipped with a system of direct injection being able to apply four different herbicides at same time.

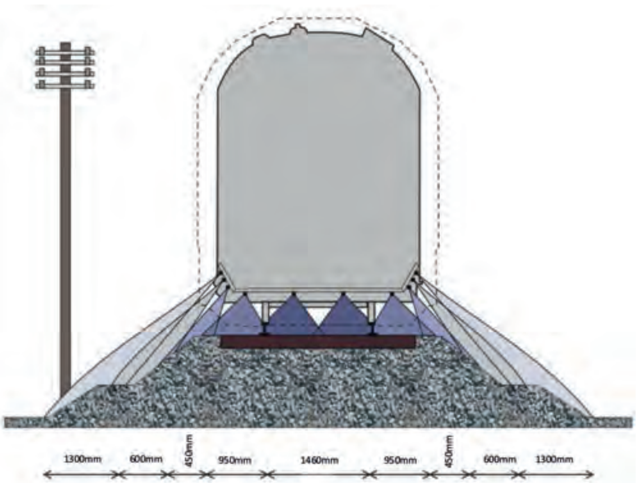

Fig. 2. Schematic image of the spray train showing the position of the nozzles and the nine different sectors were it is able to perform the application separately from each other. (Phot. G&G).

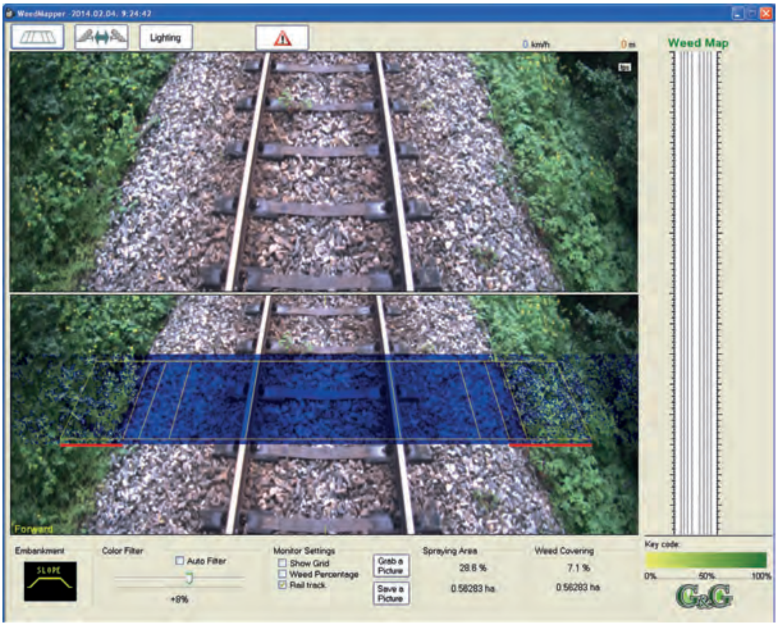

Fig. 3. Screen-shot of the control program of the spray train. Above the tracks are shown from the position of the weed detecting system, beneath are the nine different sectors which can be used for autonomous application. On the right side a weed map is compiled with all detected weeds and their GPS position. (Phot. G&G).

The sensitivity and accuracy of application was tested in the first test procedure using samples of different sizes (3x3cm, 5x5cm, 10x10cm, 20x30cm and 30x40cm) made of artificial turf. A total number of 50 of these samples were placed in a certain design within all sectors of the railroad track. Beside each sample a piece of water sensitive paper of same length as the sample was placed for application control. The experiments were done with different speeds of the spray train (40 km/h and 60 km/h) and were repeated twice. The spray train performed the application using pure water on a basis of 350l/ha. The following picture shows a scored test object (4).

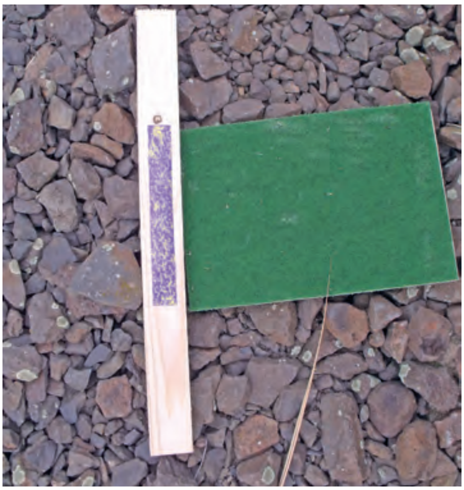

Fig. 4: Scored test object along the test track being 20x30cm of size. (Phot. Pályi)

To find out about the longitudinal distribution of the application system was the objective of the second test procedure. This test was important to answer the question in which distance to a detected test object the application starts, from which distance to the test object the application dose was a 100% and how far behind the test object these 100% would last and when did the application ended. Therefore, the test tracks were loaded with 95 test objects of different sizes (5x5cm, 10x10cm, 20x30cm) in a certain design. The test was repeated once. In this and all following test procedures a 0.25% nigrosine solution was used with an application dose of 350l/ha. Instead of water sensitive paper the test objects were equipped with filter paper. The filter paper was laid out 4m before and 4m behind the test objects (Fig. 5). The decision where the application started/ended and where it reached a dose of 100% was made by sight inspection.

Fig. 5. Measurement of the longitudinal distribution of the spray train with filter paper. (Phot. Wegener).

Within the third test procedure the lateral distribution of the application system was tested using 95 test objects of different sizes (5x5cm, 10x10cm, 20x30cm) in a certain design. In this context not the variation-coefficient was aim of the test, but the question if the application system confirms its total working width and the working widths of each separate sector under practical conditions. Furthermore it was tested how the spraying systems behaved if a test object is right in between two sectors. The test was done at a speed of 40km/h and was not repeated. The quality of the lateral distribution was judged by sight inspection.

Fig. 6. Testing the lateral distribution of the spray train with filter paper. (Phot. Wegener).

To test the influence of different lighting conditions on the weed detection system was the aim of the fourth test procedure. All three test tracks were used for this experiments at five different times (6:40 a.m., 12:10 p.m.,6:45 p.m., 8:45 p.m., 9:50 p.m.) and loaded with 95 (test track 1) and accordingly with 37 (test track 2 & 3) test objects of different sizes (5x5cm, 10x10cm, 20x30cm) in a certain design. The test was done at a speed of 40 km/h. The decision if the test object were scored by the spray train was made by sight inspection of the filter paper laid out beside the test objects.

In the fifth test procedure the determination of the switching delay of the application system was the aim of the experiment. In order to find out two marks with a distance of 150m were painted on one test track. The GPS-data of the positions marked were uploaded to the spraying system. The area in between those two marks was simulating a "restricted area" where the application of herbicides is forbidden. Within the experiment the spray train drives down the track with running application and should shut down the application system as close as possible before the first mark and start the application again as close as possible behind the second mark. In order to determine the switching delay 4m of filter paper were laid out before and behind the two marks. The results were analyzed by sight inspection.

Results

As a result of the methods used to judge about the weed detection system and the quality of the spray train´s application a number of tables were composed (Fig. 7). Within these tables the weed map and spray map compiled from the computer system of the spray train were combined with the design of the placement of the test objects and the results of the sight inspection. Thereby, these tables include all information about the tests done in one figure. In a further step all of these tables were analyzed according to misdetection (detection and application without the presence of a test object) of the system.

Distance to zero-point [m]	Banquet ri.			Bank ri.			Shoulder ri.			Rail ri.			Middle			Rail le.			Shoulder le.			Bank le.			Banquet ri.		
0,53		0	0		0	0		0	0		0	0	0,5	1	1		0	0		0	1		0	0		0	0
1,64		0	0		0	0		0	0		0	0		0	1		0	0	1,5	1	1		0	1	1,5	0	0
2,20		0	0		0	0		0	0		0	0		0	0		0	0		0	0		1	1		0	0
2,75		0	0		0	0		0	0		0	0		0	0		0	0		0	0		1	1		0	0
3,86	3,5	0	0		0	0		0	0		0	0		0	0		0	0		0	1	3,5	0	0		0	0
5,53		0	0		0	0		0	0		0	0		0	0		0	0		0	1		0	0		0	0
6,64		0	0		0	0		0	0		0	0		0	0		0	0		0	1		0	0		0	0
7,75		0	0		0	0		0	0		0	0		0	0		0	1	7,5	1	1		0	0		0	0
8,87		0	0		0	0		0	0		0	0		0	0		0	1		0	1		0	0		0	0
9,98		0	0		0	0		0	0		0	0		0	0	9,5	1	1		1	1		0	0		0	0
10,54		0	0		0	0		0	0		0	0		0	0		0	1	10,5	0	1		0	0		0	0
11,65		0	0		0	0		0	1		0	0		0	0		0	1		0	0		0	0		0	1
12,76		0	0		0	0		0	1		0	0		0	0	12,5	1	1		0	0		0	0		0	1
13,32		0	0		0	0	13,5	1	1		0	0		0	0		0	0		0	0		0	0		1	1
13,87		0	0		0	0		0	1		0	0		0	0		0	0		0	0		0	0	14,5	0	1
16,10		0	0		0	0		1	1		0	0		0	0		0	0		0	0		0	0		0	0
16,65		0	0		0	0	16,5	0	1		0	0		0	0		0	0		0	0		0	0		0	0
17,76		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0
18,87		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0
19,98		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0
21,09		0	0		0	0		0	0		0	1		0	0		0	0		0	0		0	0		0	0
22,20		0	0		0	0		0	0	22,5	0	1		0	0		0	0		0	0		0	0		0	0
23,31		0	0		0	0		0	0		0	1		0	0		0	0		0	0		0	0		0	0

Detected Area — Applicated Area — Objects scored — Objects not scored

Fig. 7. Example showing the tables being composed to jugde about the working quality of the weed detection systems and the application system of the spray train. The first column shows the distance of the measured event from the zero point of the test track. The following columns show each of the nine sectors.

Lessons learned

What can be learned from this test procedures is, that first of all the tests done are quite extensive, complex and expensive. The preparations (herbicide treatment of the test tracks) have to be done weeks in advance and a test track has to be available at all. The positioning of the test objects including water sensitive or filter paper along the test tracks is time and staff consuming. Due to the repetitions done concerning the tests under different lighting conditions the work days have been quite long, too.

The utilization of 0.25% nigrosine solution combined with filter paper is a sufficient method in order to judge about the working quality by sight inspection. What could be enhanced is the test object itself. Concerning the sensor system the artificial turf used is only a 2-dimensional object. A result of the first experiment was that test objects being smaller than 5x5cm are not detected under any circumstances. Despite this fact the sensor and the spraying system often triggered at positions where no test objects were laid out. In these cases we usually found "green objects" on the tracks (e.g. garbage, drifted leaves, sprouting weeds) which were mostly smaller than 5x5cm. From this experience we assume that the utilization of 3-dimensional test objects would be a better way in order to judge the whole ability of the weed detecting system. Furthermore, the repetition of the test under different lighting situations is a very important thing which must be done in order to judge about the quality of the weed detector, since the impact of different lighting conditions on the results can be significant under certain circumstances.

Session 3: Correct use of sprayer inspection harmonized test methods and definition of additional test methods for application equipment not covered by harmonized standards (TWG 3)

Results of the inquiry carried out in EU MS aiming at (1) the definition of the most critical issues during the inspection according to existing EN 13790 series and (2) identifying PAE types/technical items not yet considered by EN ISO 16122 series.

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Abstract

Among SPISE WG Activities, the Technical Working Group 3 deals with the implementation of current standards EN 13790 part 1 and part 2, methodologies in use and new methods in perspective. Both field crop sprayers and bush and tree crop sprayers are concerned.

A virtual questionnaire was sent to Member States delegates in order to identify differences in the interpretation of the requirements among Member States as well as differences in terms of practices. The measurement of the pump capacity that can be achieved either by a direct measurement or through nozzle size requirements, the use of horizontal or vertical patternators, the test mode for nozzles and related settings are implemented differently depending on the country or province. All answers were anonymous.

A second part of the questionnaire concerns a prospective study on the implementation of future EN ISO 16122 series. It was asked whether MS delegates were aware of the future publication of EN ISO 16122 parts 1 to 4 and had the opportunity to read at least one the draft documents. Finally, the questionnaire focuses on the definition of sprayer inspection methods for new kind of machines.

1- implementation of EN 13790 1 (Field crop) & 2 (bush and tree crops)

EN 13790-1&2 are the current standards in use to achieve sprayer inspection in Europe. Questions and § numbers cited in this questionnaire will refer to those two standards. A certain number of mandatory requirements are related to the control of key components or functions of a sprayer, such as:

4.2. Pump capacity
4.3. Agitation
4.4. Spray tank
4.8. Measurements on Boom and Nozzles… (if relevant)

Q1 The pump capacity is generally not easy to assess directly. How do you proceed in your country/province ?				TOTAL 17
	FCS		SBTC	
A. Flowmeter (5.2.1a)	9	53%	8	47%
B. Undirect measurement (5.2.1b)	10	59%	10	59%
C. No evaluation is required	1	6%	1	6%

FCS : Field Crop Sprayers – SBTC : Sprayers for bush and tree crops

Comments :

(1) "It's better to evaluate the agitation capacity, problem is that values for new sprayers are not known"

(2) "If the pump capacity is not known 5.2.1 b is used"

(3) "If no information on pump is available, 5.2.1b may be used. Pump data is provided during training of inspectors

(4) It depends from region to region. For example in Piemonte Region the pump capacity in indirectly evaluated (B) but in Lombardia Region in evaluated with a flow meter (A). In any cases,

(5) "it depends from region to region"

Synthesis question 1

Quite similar numbers are found concerning the direct or the indirect measurement of the pump flowrate among countries/provinces. In some countries, a flowmeter is a mandatory equipment of the inspection workshop even if the measurement is not done in practice. In one other case, data provided by the manufacturer on pump flowrate are given to the workshops.

2- Do you have a prescription about the minimum or the maximum nozzle size that has to be present on the sprayer during the inspection?

	FCS		SBTC	
A. No prescription, the nozzles sizes correspond to those provided on the	16	94%	16	94%
B. Yes, there is a prescription on the minimum size of nozzles				
C. Yes, there is a prescription on the maximum size of nozzles	1	6%	1	6%
D. Yes there is a prescription but the inspection workshop/unit has a provision of its own set of high flowrate nozzles to conduct the test				
			TOTAL	17

FCS : Field Crop Sprayers – SBTC : Sprayers for bush and tree crops

Comments :

(1) "If using different nozzles sizes (multi body) all nozzles sizes /types shall be inspected"

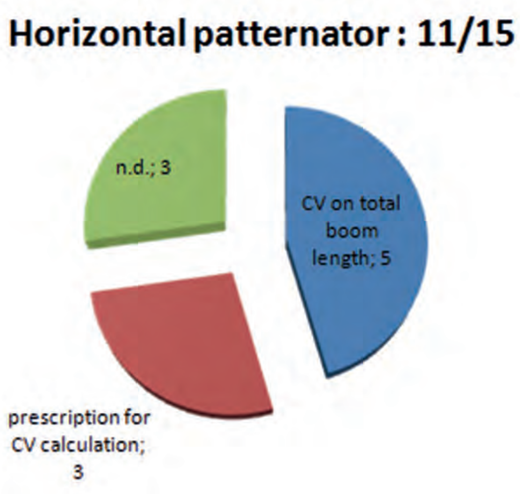
(2) "All nozzles present on the sprayer must be tested and in good condition, else removed or replaced"

Synthesis question 2

A large majority stands for no peculiar prescription on nozzle size.

3. The use of horizontal or vertical spray patternators

3.1. Horizontal patternator for field crop sprayers



3.2. Vertical Patternator for Sprayers for bush and tree crops.

Only 3 replies were positive.

Comments :

(1) "No use of patternator... Too difficult to find some well adapted areas (closed and large enough to accept booms over 28 m width).. Otherwise you will have to travel on roads for long distances and sprayer are not made for that !"

(2) "NL used to use vertical patternator, but next year it will be optional"

(3) "Most workshops use the program/software provided by the test equipment manufacturer mainly AAMS"

(4) "Scanners from AAMS and Herbst are used, they calculate automatically."

(5) "Neither horizontal nor vertical patternators are used during the inspection. Only nozzle flow rate is measured in both cases"

(6) "A) Horizontal patternator in used only to evaluate optimum boom height. CV calculation in not request because distribution uniformity in evaluate by nozzles flow rate measurement.

B) a) The most widely used is vertical try patternator; in some regions is also used vertical lamellae patternator b) to reach a symmetry index between the sprayer pattern of the two sprayer sides <10"

(7) "Horizontal patternator is mandatory for all field sprayers in Switzerland. Experiences are very good and especially the sensitization of the staff of testing stations and farmers is perhaps the most beneficial point of using horizontal patternators. --> Our problems is not the technical equipment but the sensitization and training of the users. Vertical patternator for bush and tree crops sprayers is not mandatory but used by some testing stations. The CV is in practice not of interest. They use the max. deviation per nozzle of +/- 20 % from the mean. Most of the testing station state that 20 % is too high. Most of them change nozzles even if the deviation is lower than 20 %..."

(8) "NSTS has patternation as an optional requirement"

(9) "The distribution has to be kept within two lines max/min +/- 15% of average (0). Additionally also the nozzle output for every nozzle is measured (uniformity)"

(10) "We do not use horizontal or vertical patternators."

Synthesis question 3

11 replies out of 17 indicated the use of a horizontal patternator. In most cases the CV is calculated directly by the software provided with test bench. Very few use of a vertical patternator (3/17).

4. Nozzle flow rate and pressure drop measurements

FIELD CROP SPRAYERS	
Tested nozzles are mounted on the boom (ref 5.2.5.1)	13
Nozzles are tested with the help of a test bench (ref 5.2.5.2)	2
Pressure drop is measured at a standard pressure (i.e. 3 bar)	11
Pressure drop is measured at the highest pressure permitted by the circuit	1
Pressure drop when closing sections is measured a standard pressure (i.e. 3 bar)	12
Pressure drop when closing sections is measured at the highest pressure permitted by the circuit	1
BUSH AND TREE CROP SPRAYERS	
Tested nozzles are mounted on the boom (ref 5.2.5.1)	15
Nozzles are tested with the help of a test bench (ref 5.2.5.2)	1
Pressure drop is measured at a standard pressure (i.e. 3 bar)	9
Pressure drop is measured at the highest pressure permitted by the circuit	1
Pressure drop when closing sections is measured a standard pressure (i.e. 3 bar)	9
Pressure drop when closing sections is measured at the highest pressure permitted by the circuit	1

Comments :

(1) "Pressure drop and pressure drop when closing sections are measured at 8 bar"

(2) "Pressure drop: result of this test in not binding. Generally, the test pressure is the working pressure indicated by the farmer"

(3) "Pressure used is as appropriate to the equipment, not specified as 3 bar in either cases"

(4) "Pressure drop is measured at the pressure for practical use."

(5) "Pressure drop measurement: generally not mandatory. In general the reference pressure is the working pressure indicated by the farmer"

(6) "The standard pressure is at least 4 bar for field crop sprayers and pneumatic ones (if permitted by the pump). It is about 15 - 20 bars for orchard sprayers. Nozzle can be tested on the sprayer or dismounted if the pressure is recorded during measurement AND the accuracy of the measure reaches the minimum level of 2.5%"

Synthesis question 4.

At a large majority, nozzles are tested on the boom/sprayer. Few answers (3/17) indicated the use of a test bench to check nozzle flow rate. Pressure drop and pressure drop when closing section are generally performed at a standard pressure. Only one answer indicated that those last tests are performed at the highest pressure. Health and safety issues are cited in comments.

5. Additional measurements according to EN 13790 1-2 (comments only)

(1) "Belgium focused on the European Directive 2009-128 EC Annex II to make the necessary adaptations of its inspection protocols. So Belgium fulfills normally 100% to Annex II but some points of EN13790 are not checked :

§4.2.3. Pressure safety valve not tested : Reason difficult to perform and danger to damage sprayer during inspection.

§4.4.3. Chemical introduction container grating: Not checked no environmental danger or danger for user.

§4.4.4. Pressure compensation in the tank: Not checked no specific reason

§4.4.6 Collect the emptied spray liquid: Not checked no specific reason danger or danger for user.

§4.4.9 Cleaning device for crop protection product containers : Not checked no specific reason points not checked for EN13790-2

§4.4.7 Non return device for water filling: Not checked no specific reason

§4.7.2. Isolating device present to clean filters without emptying sprayers: Not checked no specific reason Comparable

§4.4.8 Chemical introduction container: Not checked no environmental "

(2), (3), (4) No comment

(5) "Pressure Safety valve "

(6) "In practice most manometers are only tested if they don't work correctly during the test."

(7) "French protocol is closer to EN ISO 16122 than EN 13790"

Partial conclusion on EN 13790 part 1 and 2 use among countries/provinces

Some discrepancies are identified in the interpretation of existing standards/regulations. One fundamental question is related to what has to be controlled/tested. Is it the maximum capacity of the equipment?; is it the running conditions of the equipment as used by the farmer ?; is it the minimum requirements

Some answers let appear the lack of coherence between EN 13790 and 2009/EC/128 directive requirements on some aspects. Finally, some answers raised the principle of « reality » in terms of what is reasonably testable on a sprayer, in a workshop or in a farm courtyard.

6. Future implementation of EN ISO 16122 series

New standards for the inspection of sprayers (EN ISO 16122 series) may be published in a near future. Several categories of sprayers are already identified :

EN ISO 16122 part 1 : Categories of sprayers

EN ISO 16122 part 2 : Horizontal boom sprayers

EN ISO 16 122 part 3 : Sprayers for bush and tree crops

EN ISO 16122 part 4 : Fixed and semi-mobile sprayers

I had the opportunity to read at least one of the EN ISO 16122 projects :	15
I foresee problems in the implementation of these standards.	5

Comments

(1) "I had not the opportunity to read any of EN ISO 16122 projects."

2) ""Problems" all inspectors need to be trained. New demands like travel speed, sensors etc will come. The pretest in part 1 will make the test take longer time, but is very valuable."

(3)"On the 16122 part 4 Belgium voted negative because of the implementation of a pump test on sprayers built according 16119-4."

(4) "It is necessary to have soon new standards for the inspection of others type of sprayer as knapsack mist blower, train sprayer, foggers ."

(5) "The problem with these standards is that they shall be taken in use by inspectors and not as normally industrial companies. Thus the price per standard is one thing; the other is the need of very many standard to be bought by the inspector (references to other standards in one standard and several standards for one type of sprayers). Thus SPISE should find a practical solutions of a more user friendly set (like made e.g. in Sweden) and a solution to an acceptable price.

It also has to be found a practical solution of the accreditation for the inspection units. It has to be taken into account that some countries have several units with a low number of inspections due to the infrastructure and size of country and more mobile units in order to visit the operators and ensure that the operator join the inspection, when other countries have workshops were several hundreds of sprayers are inspected at the same location and rarely have the possibility to have the operator present. If too complex the costs per inspection will increase and the motivation of the operator will decrease."

(6) "Measuring capacity pump instead of measuring and evaluating agitation capacity"

(7) "Concerning part 4, the measure of the backflow can be very difficult in practice and highly time consuming"

Synthesis on question 6 :

A large majority had the opportunity to read at least one of EN ISO 16122 series. Some technical problems are foreseen. A too complex method or equipment may generate difficulties for itinerant workshops realizing fewer inspections than fixed ones.

7. Inspection of sprayers not considered by existing EN ISO 16122

10 answers were given.

	Portable	Foggers	Trains	Aerial
Inspection is done	4	2	6	3

Inspected items :

Parameter	Portable	Foggers	Trains	Aerial
Pump capacity	3	1	7	1
Pressure	5	3	6	2
Flowmeter	3	2	5	1
Forward speed	2	1	3	
Spray distribution	2	2	3	
Nozzle flowrate	6	4	7	3
Pressure drop	5	1	6	2
pressure drop when spray off	2	1	4	1
Pressure distribution	3	1	4	1
backflow for agitation	3	2	4	1
direct injection	3	2	4	1
application volume	4	2	6	3
spray range	2	1	4	1
agitation	4	2	6	1

Comments :

(1) "none of these equipments are inspected yet"

(2) "Today, only train sprayers are tested in an own, voluntary system in SE. This will be adjusted to EN ISO 16122..."

(3) "At the moment Belgium is inspecting - Field crop sprayers - Orchard and Vineyard sprayers - Greenhouse and similar sprayers (Fixed and semi mobile sprayers) -

Soil disinfection machines Portable sprayers: Approximately 10 portable plot-sprayers are inspected at this moment with the Belgian "greenhouse sprayer" protocol.

This works but fits not 100% on those types of sprayers. At this moment, we perform no other inspections on other types of portable sprayers.

Foggers: No inspections at this moment. Belgium is waiting for a Standard. Train sprayers: Only one train sprayer has been inspected at this moment in Belgium, but no specific protocol was developed for this purpose. A tailor made inspection was performed, mainly based on existing field - crop protocol in Belgium and EN13790-1 standard. Furthermore, a number of railway sprayers mainly based on Unimog's are inspected by using the Belgian field crop spray protocol. Aerial sprayers : No aerial spraying in Belgium."

(4) "Portable sprayers: actually inspected only in some regions"

(5) "Only one helicopter in use. Nozzle type, drop size and distribution for train and helicopter are set due to the high speed in use in order to avoid drift.

For trains we normally also do deposit tests by the use of WSP with a speed about 20 km/h.

For helicopter, we have made deposit tests due to 60-70 km/h and 4-5 m height with nigrosine and paper rolled out perpendicular to the driving direction.

A stationary distribution test for such equipment may be incorrect if not taken into account the high speed in use.

Because the nozzle used do minimize the risk of drift (proved by experiments) we only make stationary test with these nozzles normally for the annual inspection.

I also like to add that inspection of foggers may be very difficult because of the high concentration of pesticide in practical use.

Thus here the inspection should have been carried out by a test fluid (with properties of pesticides but not toxic) or by the use of the pesticide itself.

Parameters like house construction, fogger position, RH and temperature and the mass of plants may influences and require different set up & ventilation etc and have to be taken into account (somehow..)

Why pump capacity is not measured on the helicopter is that it is used a easy mixable pesticide (Glyphosate) and also that it is complicated to fix a flow meter to the pump below the helicopter.

For helicopter use, we have to keep in mind that failures like variations in height (difficult terrain in forest), variations in swath width and variations in speed e.g. at the end of track give more variations than minor failures on e.g. pressure. The nozzle output is rather large due to the high forward speed (ca 4,7 l/min). In the helicopter a flow meter is installed. We measure nozzle output and check if this value corresponds to the flow meter in the helicopter (and adjustments are made if necessary)"

(7) "We have regulations on how to inspect the train and the aerial sprayers and some

workshop interested in to do the inspections, but the inspections are not performed yet.

For the aerial sprayers only functional tests are to be performed. We wait for new standards to follow up."

(8) "Train sprayers are currently inspected once a year, but on a voluntary basis."

Synthesis on Question 7

Train sprayers are already inspected by 6 countries/provinces out of 17 without a harmonized EN ISO protocol. 6 technical items are mostly preferred for the inspection related to nozzle flow rate, pressure distribution and pressure drop, application volume and agitation. The question of static measurement for trains, aerial sprayers is raised. The second most cited sprayers are portable ones.

8. If not already inspected, what would be your preferences?

10 positive replies.

Parameter	Portable	Foggers	Trains	Aerial
Pump capacity	3	2	7	3
Pressure	8	3	8	7
Flowmeter	4	3	7	6
Forward speed	3	2	6	2
Spray distribution	5	4	6	3
Nozzle flowrate	8	6	8	6
Pressure drop	6	3	6	5
pressure drop when spray off	2	3	5	3
Pressure distribution	3	2	5	4
backflow for agitation	1	3	7	3
direct injection	2	3	7	2
application volume	7	7	6	4
spray range	6	4	6	4
agitation	5	4	6	3

Comments

(1) "We will probably demand that sprayers on train and aircraft are inspected (according to a standard if there is one) to be allowed to use but we will probably not have any Swedish inspections scheme"

(2) "I'm not sure what portable sprayers are in this connection"

(3) "Belgium has started up a specific project (SIRA-APESTICON) in order to give an answer on Chapter III, Art 8 point 3. It exists mainly out of the following 3 steps:

a. Determining which PAE is used on Belgium territory. (Kind, Numbers, Type of pesticide,...)

b. Developing a risk analysis method to research if derogation is applicable for identified PAE.

c. Developing new inspection protocols where applicable"

(4) "In Switzerland we have the opinion that training of users is much more important than

controlling portable sprayers. Train sprayers are not in use anymore and very few aerial applications occur. Foggers are not tested."

(5) "A problem with portable sprayers is that (i) an inspection will cost more than buying a new one, and (ii) failures may occur between the inspections.

Additionally wrong dosage, bad safety and environmental problems as well as poor effect may occur more due to misuse of the sprayer. Thus information and skilling in proper calibration, check for leaks, nozzle variety, by simple means for ensuring a good application without risk for operator or environment will motivate better the grower to buy a better sprayer when needed and USE the sprayer in a correct manner and also avoid huge residues of spray volume at the end."

(6) "The new regulations are in the final step but still in progress. It will cover: glasshouse sprayers, foggers, seed treatment, granules application, other spraying equipment with the tank volume of less than 30 l.

Only for glasshouse sprayers, there is a proposal to measure pressure drop and nozzle flowrate, for the rest of equipment - functional tests and visual inspection."

(7) "Protocols are more or less definitive... equipments to be inspected in 2015"

Synthesis question 8.

Trains, portable sprayers and aerial are the most cited sprayers to be inspected. Technical items to be inspected are the same as cited in question 7. Some comments introduce the question of risk assessment for some sprayers and the need to take into account the real case scenario (use of sprayer, chemical sprayed, etc.)

Conclusion

A detailed inquiry among Member States showed how inspection workshop deal with the inspection of sprayers regarding related standards and the implementation of the Annex 2 of EC/128/2009 directive. The implementation of EN 13790 showed differences in different Member States or provinces.

EN ISO 16122 projects are more or less known by ~10 MB. Additionally, some sprayer types not covered by EN ISO 16122 yet are already tested by some MS.

A potential for existing methodologies in some countries might be beneficial to CEN developments. Trains are priority number one followed by portable and aerial sprayers.

Some questions raised the problems of the access/cost of standards for individual workshops.

Consideration to inspection workshops size and volume of activity are also evoked.

References

EN 13790–1, 2003. Agricultural machinery - Sprayers - Inspection of sprayers in use - Part 1 : field crop sprayers

EN 13790-2, 2003. Agricultural machinery - Sprayers - Inspection of sprayers in use - Part 2:Air-assited sprayers for bush and tree crops.

EN ISO 16119-1, 2013. Agricultural and forestry machinery – Environmental requirements for sprayers – Part 1: General

EN ISO 16119–2, 2013. Agricultural and forestry machinery – Environmental requirements for sprayers – Part 2: Horizontal boom sprayers

EN ISO 16119-3: 2013. Agricultural and forestry machinery – Environmental requirements for sprayers – Part 3: Sprayers for bush and tree crops

PR EN ISO 16122-1, 2013. Agricultural and forestry machinery - Inspection of sprayers in use - Part 1: general

PR EN ISO 16122-2, 2013. Agricultural and forestry machinery - Inspection of sprayers in use - Part 2: horizontal boom sprayers

PR EN ISO 16122-3, 2013. Agricultural and forestry machinery - Inspection of sprayers in use - Part 3: vertical boom sprayers, mist blowers and similar

PR EN ISO 16122-4, 2013. Agricultural and forestry machinery - Inspection of sprayers in use - Part 3: fixed and semi mobile sprayers

Inspection of Fog and LVM application equipment in the Netherlands

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Introduction

In the Netherlands is the inspection of field and orchard sprayers mandatory since 1997 and 2002. But with the implementation of the EU directive for a sustainable use of pesticides (2009/128/EC) also the periodical inspection of other types of application equipment will be mandatory before the end of 2016. From the end of 2014 the obligation to inspect these machines is gradually introduced, depending of their year of construction. This includes also the periodical inspection of Low Volume application equipment like thermal (fog) and compression (LVM) misting machines used for the application of pesticides in greenhouses and potato storage.

Definition of the equipment

The definition of Low Volume application equipment is: 'Equipment which produce very small 1-50 µm droplets used for a special treatment of pests with Low Volume Application Rate.'

In general there are two types of this equipment, based on their difference of energy source to create droplets:

- Fogging (thermal misting): Thermal energy used to create and transport droplets

- LVM (compression misting): Energy from compressed air used to create droplets and transport by additional fan.

Inspection of Low Volume Application Equipment

For this type of equipment no (harmonized) EN or ISO standard is available or in development at the moment what can be used for the periodical inspection of the machines in use. Therefore SKL in the Netherlands has developed their own inspection protocol. This is done on base of Annex II of 2009/128/EC with the use of the systematics and relevant content of the already existing EN-ISO 16122 series.

This inspection protocol was developed with the assistance of experts and manufacturers of Fog and LVM equipment. One of the problems arising is, that there are also no standards for new equipment, and there is a wide variety and diversity of machines on the market.

On base of this first inspection protocol the first machines (manufactured before 1996) are inspected this year. The end of the year this protocol will be evaluated on base of this first experience and can be used for input for the development of harmonized EN-ISO standards in the 16122 series.

Inspection protocol

One of the most important conditions for a good functioning of this type of machines is their general state of inner-cleanness and state of maintenance.

Before starting the inspections the pre-inspection of EN-ISO16122:1 is used, for LVM equipment special attention has to made on the internal cleanness of the machines and for Fogging equipment the conditions of EN-ISO16122:1 are complemented with the following conditions:

- Condition exhaust pipe
- Recent maintenance (max. ½ year since the last maintenance)
- Relevant part are renewed:
    - Spark plug
    - Valves in fuel system
    - Valves in fluid system
    - Membrane in carburettor

Because high concentration of pesticides is used with this type of machines, special attention has to made also on the outside cleanness of the machines in order to decrease the risk of the inspector.

During the inspection all relevant parts are checked. For most elements this is a visual inspection. The flow of the nozzle is checked on base of data what has to be supplied by the manufacturer. For most machines this data is not available at the moment, so cooperation of the manufacturers is important to supply the relevant data.

The inspection is finalised with a visual check of the misting pattern.

Based on this protocol special inspection reports are developed based on the general requirements of EN-ISO 16122:1 paragraph 7.

In the Netherlands is decided that the inspection frequency of this machines is every 6 years instead of 3 years for the other types of application equipment.

Conclusion

Because of the lack of existing relevant standards for the inspection of Fog and LVM equipment in use, SKL in the Netherlands has developed his own testing protocol. It appears that developing a general inspection protocol for this type of equipment is difficult because of the missing of standards for new machines, the wide variety of machines and types on the market and the missing of relevant data of flow-rates for nozzles.

For the nearby future harmonized standards for both new (EN-ISO16119) and for testing machines in use (EN-ISO16122) are needed for uniform testing across Europe.

The inspection of soil-disinfection equipment in Belgium.

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Summary.

In Belgium, the mandatory inspection of field and orchard sprayers was already started up in 1995. At that time, there were only inspection protocols available for those two types of sprayers. From 2008 on, two new inspection protocols were developed: one for greenhouse sprayers and one for soil-disinfection machines. Those inspection protocols were added to the Belgian legislation and implemented since 2011. The inspection protocol for greenhouse sprayers was mainly based on the two existing protocols (field and orchard sprayers) as the working principle of those machines was similar.

Soil disinfection machines used on Belgian territory needed another approach because of the differences in pressurising and application technique compared to classical spraying machines. Soil disinfection machines use a closed tank containing the vaporous disinfectant. The tank is pressurised by a compressor or a diving cylinder. As concerns the injector side of those machines there are different possibilities. Some are using a manifold with restrictor plates or a small tap per injector, others use narrow tubes towards the injectors, and sometimes nozzles are used.

As one can see, there are no standard inspection methods available for those types of machines. Neither a standard spray pattern measurement, nor a separate pressure and nozzle testing is possible on most of those machines. On top there are some important safety aspects that need special attention due to the hazardous products used.

The Belgian inspection protocol was almost completely developed in-house and makes it possible to inspect soil-disinfection machines in an accurate, safe and economical way.

Key words: sprayers, soil-disinfection, inspection, results, defects

1. Introduction.

Since 1995 sprayer inspection became mandatory in Belgium which makes it one of the forerunners in this field in Europe. At that time, the bad technical condition of the sprayers, the excessive supplementary costs for the farmer arising from an inefficient pesticide use, the negative impact on the environment and the necessary restructuring of the European Agriculture to keep it competitive after the CAP reform and GATT negotiations, were the main reasons for the implementation of the sprayer inspection. Now, the Framework Directive for a sustainable use of pesticides introduces the inspection for all pesticide application equipment in professional use in Europe.

In many ways, the mandatory inspection of sprayers in Belgium differs from inspections in other European countries. The FAVV/AFSCA (Federal Agency for Food Security) is responsible for the inspection but it delegates the inspection to two regional bodies: ILVO (Flemish region) and CRA-W (Walloon region). Those two official bodies are also BELAC accredited according to ISO 17020 which guarantees a maximum quality of the performed inspections. The inspection teams (3 in the Flemish region and 2 in the Walloon part) are equipped with a test van that contains all necessary equipment to perform the inspections according to the Belgian federal legislation (Fig. 1). The inspections are carried out at a neutral location where farmers/contractors are invited at an exact date and time, to present their sprayer for testing at this place. All over the country test locations are hired in a way that farmers/contractors don't need to travel distances > 15 km with their sprayers. On demand inspection teams also perform inspections at the farmyard, but therefore an extra fee is charged. The inspection procedure is based on the analytical principle which means that all parts of the machine are tested separately. After the inspection the farmer/contractor receives a certificate confirming the approval of the sprayer for the next three years or specifying all the items that need to be repaired in case of a rejection. No repairs are made to the sprayer during the inspection, so the farmer/contractor needs to repair the defects himself or leave the repairs up to a workshop. Consequently, the repaired sprayer has to be represented for a second passage.

Fig. 1. Inspection van with test equipment.

As concerns soil-disinfection equipment, a new theoretical protocol was developed and legally approved and inspections based on this protocol were started up in 2014. Before and during start-up of inspections a number of problems needed to be solved and cleared out.

2. Working principle of a common soil-disinfection machine.

In order to clarify the inspection protocol, one first needs to know how this type of machines work (Fig. 2). Therefore a hydraulic scheme is useful and a a simple scheme is shown in Fig. 3 containing all elementary parts of a common used soil-disinfection machine.

Fig. 2. Typical soil-disinfection machine.

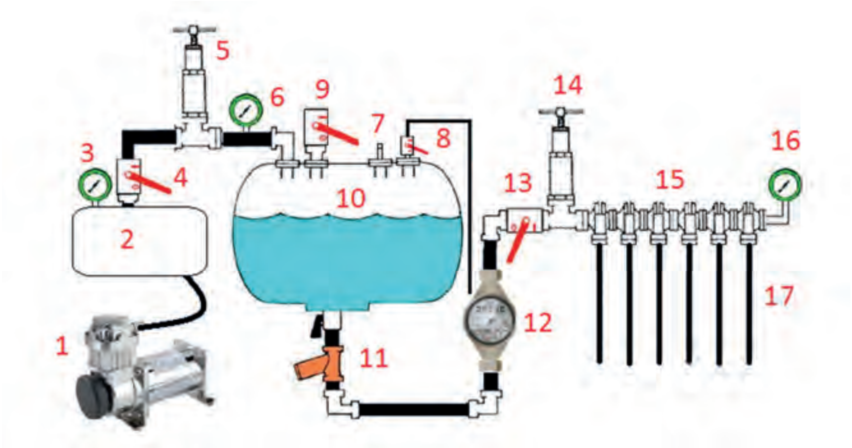


Fig. 3. Hydraulic scheme of a soil-disinfection machine.

Briefly one could divide the scheme into two main parts. On the one side you have the air pressure part (part 1-8) and at the other side the liquid pressure part (9-17).

As concerns the air pressure part, in most cases, a battery or hydraulically powered compressor (1) is used to pressurise the air-pressure tank (2), but it has to be mentioned that some specialised firms use a scuba tank for pressurising the pesticide tank (10). A pressure gauge (3) on the air pressure tank indicates the available air pressure. A valve (4) between the air pressure tank and the pesticide pressure tank (10) is available to shut off the air pressure between both tanks. Between the air pressure tank and the pesticide pressure tank a pressure valve (5) makes it possible to adjust the air pressure in the pesticide pressure tank (10) based on a pressure gauge (6). There is also a safety pressure valve (7) foreseen, and a pesticide tank depressurizing valve (8) to safely depressurize the pesticide tank.

At the liquid side the metal pesticide pressure tank (10) is sealed hermetically and there is a filling valve (9) to fill the tank with the soil-disinfectant. There is an optional pressure filter (11) and a main shutoff valve (13). A dividing block (15) with restrictor plates, small taps or narrow tubes divides the liquid to the different injectors (17). Optionally an analogue or digital flow meter (12) and an extra flow regulating valve (14) can be installed to fine-tune the flow. An extra pressure gauge (16) on the dividing block (15) is interesting to read out the pressure at injector height.

3. Problems to deal with.

At first some practical problems needed to be solved. As one knows soil-disinfection machines are used with hazardous products such as chloropicrin, metam-natrium and 1,3-dichrloropropene. Thus for testing those machines the owners were explicitly asked to clean the machines, rinse the tank and to fill it with clear water. However during first inspections, there were problems encountered with contaminated machines. Although the inspected machines looked quite proper, after half a day of testing, inspectors encountered breathing and dizziness problems. Probably the inside of some machines was not rinsed enough and there was still some contamination at the outflow of the injectors. As the owners of the inspected soil-disinfection machines were not wearing any protective equipment during testing, inspectors assumed that there was no health danger and only wore gloves and no pesticide mask. So conclusion was that one could never be sure that the machine was proper rinsed by starting up inspections.

So in order to protect the health of the inspectors, a procedure was developed for inspecting those types of machines. At first inspection of soil-disinfection machines should always be performed in open air to obtain maximum ventilation. The machine should also be positioned downwind to prevent inhalation of hazardous vapours. Inspectors are obligated to wear a pesticide mask, gloves and safety shoes. Following this basic directive should prevent further health problems.

Furthermore there are only a small number (17) of such machines in Belgium that need to be inspected, what made it necessary to search for an economical approach. As a consequence, we tried to use, as much as possible, the existing testing equipment or cheap testing equipment.

Another problem was an underestimation of the time needed for inspecting those types of machines, mainly due to a wrong inspection sequence. At first owners were asked to present their machines unpressurised, in order to firstly check the pressure gauges on a test stand and to evaluate afterwards if there are no problems with pressurizing the pesticide pressure tank. For some machines pressurisation from the tank took quite a while because of the presence of only a small compressor in combination with a partly filled pesticide tank, a large air volume was needed. So it was better to ask owners to present their machine in pressurised state in order to be able to start up the inspection almost immediately.

Last but not least it was a question how to inspect the injected pesticide volumes. As one can see it is not possible to use a normal patternator or combined pressure/nozzle measurements to define the injector pattern.

To solve all problems above a simple, safe and economical inspection method had to be developed.

4. Inspection method.

Primary before starting up the inspection, all admittance rules are overlooked. So the machine needs to be presented in a clean state and all moving parts have to be protected. The pesticide tank has to be filled for ¾ with clean water and there may not be any big leakages. Furthermore the owner is asked to present his machine in a pressurised condition (normal work pressure) to make it possible to start the inspection almost immediately.

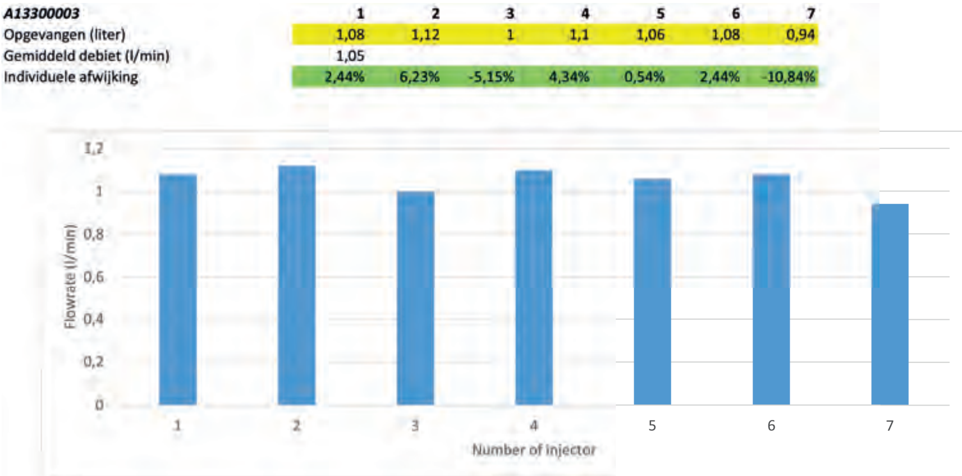
In a first stage spraying is started at normal work pressure used by the owner. The good working of the pressure adjustment valve is checked by varying the pressure and checking if pressure remains constant (less than 10% of variation) while shutting off and on the main valve. It is also checked if the capacity of the compressor (or scuba tank) to maintain the pressure in the pesticide tank is sufficient, which means that the pressure has to be stable while spraying at normal working pressure. At the same time the machine is visually inspected for leakages and also all shutoff valves should work properly (main valve, individual valves, etc.). At least one measuring instrument needs to be present to make accurate adjustments. This may be a pressure gauge and/or a flow meter.

After checking all items above, the testing of the injector/spray pattern is started up. As already mentioned, it is impossible to use standard methods to test the injector/spray pattern, such as a patternator or the combination of a pressure and a nozzle flow rate measurement. Because of the small number of such machines, a reliable, safe but economical method to measure the injector pattern was needed.

At first, pattern testing was performed with graduated measuring cups and a stopwatch as sometimes performed on normal field crop sprayers. Disadvantage of this method is that some of the injectors are very difficult to reach and with two inspectors only 3 injectors at a time can be measured. Furthermore while inspecting, the inspectors are close to the outflow of the injectors, and in some cases need to position arms underneath the machine what makes this an unhealthy and unsafe situation.

Fig. 4. Soil-disinfection machine injectors, pattern measurement.

Finally a number of identical buckets and a digital balance were bought. Before testing the pressure and/or flow is regulated to the desired values while spraying. Then the main valve is shut off and underneath each injector an empty bucket is placed. The start value of the flow meter (if present and when the flow meter is a counter) and also the test pressure is written down. Then the main valve is opened and at the same time a stopwatch is activated. While measuring, the test pressure is written down, and for real time flow meters the real time flow is registered. After minimum 2 minutes of measuring the main valve is shut off and the stopwatch is deactivated. By weighing the buckets combined with the measured time, the individual flow/flow rate (pattern) and total flow/flow rate can be determined. The flow meter value can be compared with the captured flow. A maximum difference of 10% is accepted. The inaccuracy following out of different supply pipe lengths is compensated by the long measuring period. The mean value of the flows is calculated and the difference with this mean value per individual injector may not be above 10%. As injected soil-disinfectant gets its good working from evaporating into the soil, this 10% is a satisfying limit for this type of applications.



A13300003	1	2	3	4	5	6	7
Opgevangen (liter)	1,08	1,12	1	1,1	1,06	1,08	0,94
Gemiddeld debiet (l/min)	1,05						
Individuele afwijking	2,44%	6,23%	-5,15%	4,34%	0,54%	2,44%	-10,84%

Fig. 5. Pattern of soil-disinfection machine nr. A13300003.

When the injectors use nozzles, the testing method is similar as above, except that an orchard test bench is used instead of buckets. When the pattern is bad then the machine is always rejected, but additionally the nozzles are demounted from the machine and tested on a nozzle flow rate test bench. When the nozzles are worn they must be replaced. When the nozzles are still OK the owner knows for sure he has to look at his machine to repair the problem. However during inspection, no further measurements are performed on the machine to locate the problem, because in most cases extra pressure measurements are difficult to perform, and time consuming.

In a final stage the pesticide tank is depressurised and it is checked if this can be done in a safe way, and if there is no danger for unintended opening of the tank filling valve. There also has to be a pressure safety valve. The machine in Fig. 6 has a possibility to depressurise it in a safe way with valve B and a tube that leads the air-flow downwards. However the filling valve from this machine can be opened easily when pressurised and all the air with hazardous vapours could be blown directly into one's face, so this is an unsafe situation. Here we recommend to remove the lever from the valve when the tank is filled.

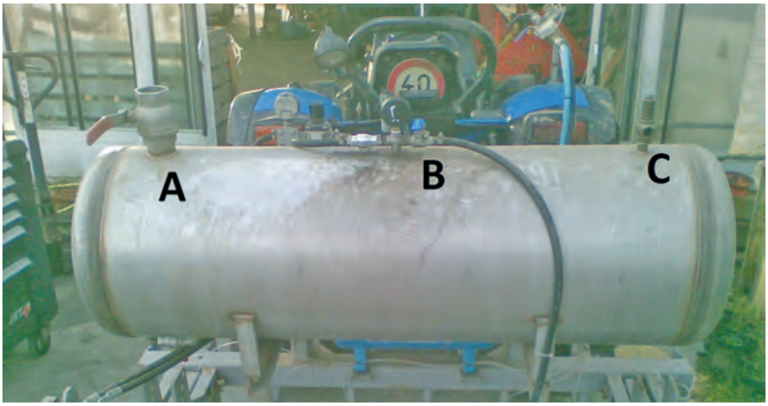


Fig. 6. Pesticide tank with unsafe filling valve (A), safe depressurising valve (B) and safety valve (C).

After depressurization, it is checked if the visibility of all measuring instruments from the operators position is sufficient. In a next step the tank contents indicator is inspected on its presence and readability. Furthermore there is also looked if moving parts are adequately protected and if the general maintenance condition of the machine is OK. Then filters are checked for their presence and when pressure problems were detected the filters are inspected for dirt or other problems.

The state of the injector knives is also inspected. They have to be in good condition and they also have to be equal. There is also looked if the injector pipes are adequately protected.

In a final stage all pressure gauges are demounted from the machine and tested separately on a manometer test stand. The pressure value may not differ more than 10% from the one read on the reference pressure gauge.

5. Conclusions

Because of their specific construction there was the need to develop a complete new inspection protocol for soil-disinfection machines. Furthermore a number of additional problems needed to be solved. At last a complete new and well balanced inspection protocol was developed.

The owners of the soil-disinfection machines are also as much as possible involved in the actual inspection and they are given advice during the inspection. All test results are registered in an official test report.

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Sprayer testing in the UK – an overview of the National Sprayer Testing Scheme

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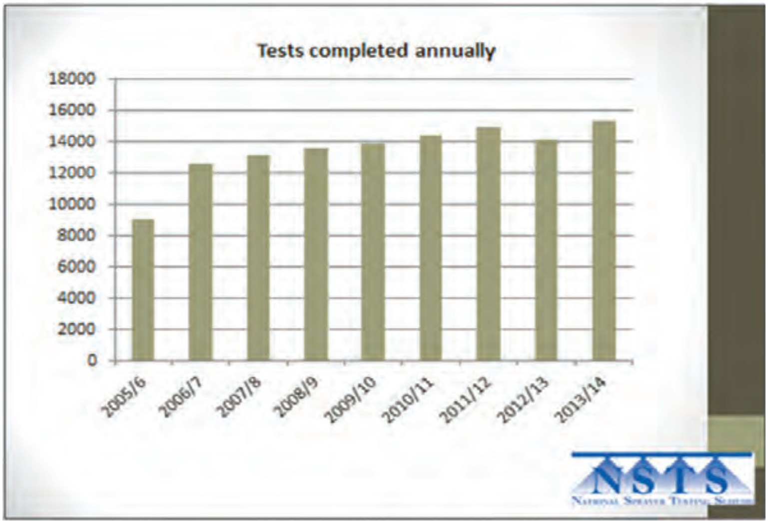
Sprayer testing commenced in the UK in 1997 when the Agricultural Engineers Association (AEA) launched their industry led testing scheme. AEA members from the sprayer manufacturing and importers sector highlighted the need for such a test, ensuring that application machinery was fit for purpose.

In 2003 the AEA scheme became the National Sprayer Testing Scheme (NSTS) and by the end of 2013 was testing over 15,500 pieces of pesticide application machinery annually. The NSTS is an annual requirement of the UK's major crop assurance, super market and grower protocols. Additionally NSTS has been delegated by the UK Government as the body to test application equipment in the UK to meet the requirements of the Sustainable Use Directive.

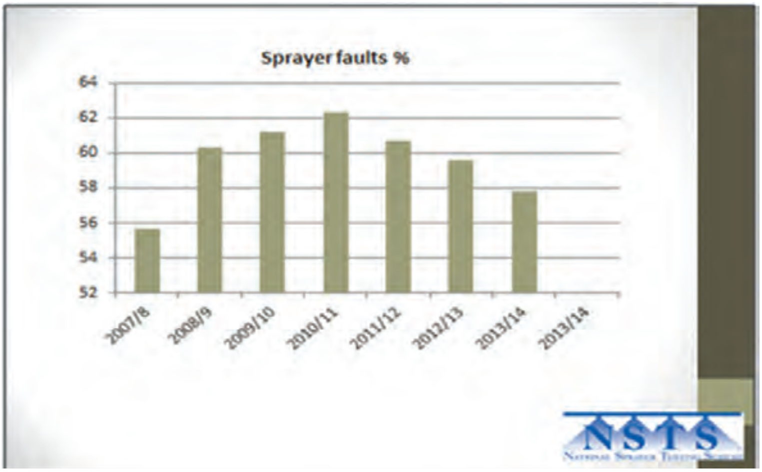


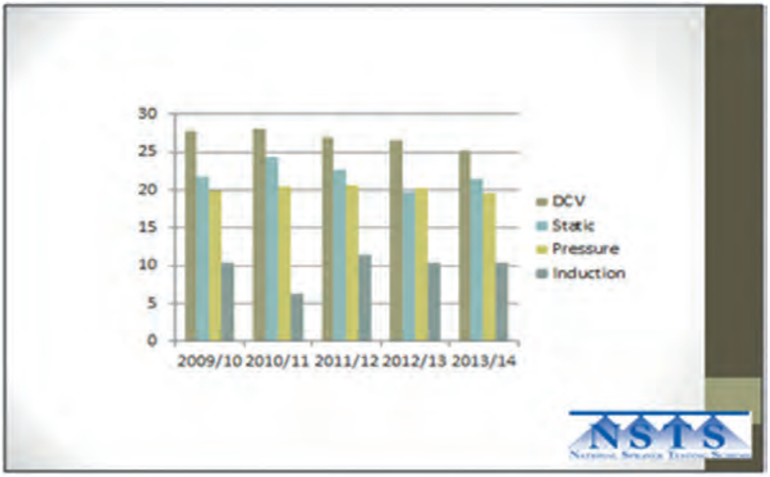
The standards employed in the scheme mirror those required by EN 13790 with additional items which increase the ability of the equipment to function correctly and apply pesticides accurately and on target while increasing safety for both the environment and the operator.

NSTS is available through a UK wide network of 213 Test Centres. These test centres employ machine examiners who have been trained and achieved the City & Guilds Level 3 Certificate of Competence in Sprayer Examining. The 579 examiners are required to attend annual examiner updates and take part in audits, all of which ensures that standards are being applied fairly and equitably throughout the network.

The NSTS has additional protocols which cover Granular Applicators, Fogging machines, Spray Trains and Aerial application and is working towards covering all the many types of equipment that will require testing as part of the SUD.

The results of the NSTS tests show that almost 58% of the machines have faults detected at the time of the examination, with leaks and drips accounting for the majority of faults. The requirements of the test ensure that the machine returns to work with all the faults rectified. The last four years have shown a steady decline in the percentage of sprayers requiring rectification.





The NSTS test will continue to be an annual requirement for crop assurance, super market and grower's protocol's, with one of the annual tests satisfying the requirements of the SUD. NSTS has set standards for machines, examiners and procedures and offers growers a proven cost effective and meaningful examination of their application equipment.

Session 4: "Certification" of the workshop activity (quality assurance) including test facilities (TWG 4)

Results of the enquiry carried out in EU MS in order to evaluate their quality assurance system for inspection activities carried out by workshops

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In the Directive 2009/18/EC of the European Parliament and of the Council establishing a framework for Community action to achieve the sustainable use of pesticides in article 8 is stated that "Each MS shall establish certificate system designed to alow the verification of sprayers inspections…."

SPISE WG has spent many years trying to create a system for the mutual recognition of inspection of sprayers. This issue is discussed at wokshops and further SPISE

TWGs meetings.

Last year (2013) was submited by the European Commission the Proposal for a Regulation on official controls…. This proposal was adopted negatively by most of the MS in terms of intention to submit the inspection of sprayers under the ISO certification /ie Article 22 - (e) the design of certification systems to assist the competent authorities in the inspections of pesticide application equipment;/ etc.

In line with WG SPISE discussions was prepared a survey for the MS concerning quality assurance system for the inspection of sprayers in use and sent to whole contacts in european countries. To the time of preparation of this paper was returned completed questionnaires from 16 countries. There are mentioned answers from participated countries below:

Testing equipment

1. question
Are the requirements for the testing equipment based on ?

EN13790/ISO16122 SE,SRB,IT,ES,D,NL,B,CZ,DK,UK,SUI, P,PL,N,F, **SK**-the test field and orchard sprayers,

different, please specify: CZ-national regulations, **UK**-plus additional items - boom suspension, folding, checks on all sprayer systems, induction hoppers,container rinse and tank wash etc., **N**-we measure flow rate as well as distribution. For distribution we use Lurmark patternators,

additional, pleae specify: IT, **SE**-National rules SJVFS 2008:1, **NL**-testmanometer must be min 150 mm and class 0.6, **DK**-We have made a Danish guideline that to a large extent follows the standard., **SUI**-Swiss regulation:

http://www.agrartechnik.ch/index.cfm?parents_id=897, **SK**-for testing air applicators and machines for seed treatment is a test device defined by the guideline TSUP MP2/2011,

comments: IT-minimum requirements for vertical patternator (NAP), **CZ**-majority of the requirements are consistent with EN13790, **D**-some few light deviations,

2. question
Is certification of testing equipment needed (JKI/ENTAM/Other)?

Yes, please specify: B,UK,P,PL,N

B-Testing equipment is certified under the rules of the ISO 17020, **F**-Only metrological check before being used, **D**-depends on Federal State, **N**-NMBU has tested the inspection devices. In Norway almost similar euquipment are used due to the equipped 70 mobile car trailers spread arend, **PL**-PIMR (Poland)-for domestic equipment, for other the certifications from producer country are accepted, **P**-The precision of the testing equipment is expected. The certication presented by the manufacturer of the equipment has been accepted, **UK**-NSTS specifies equipment requirements

No: SE,SRB,IT,ES,D,NL,CZ,SUI,SK,F

3. question
Is the testing equipment checked and calibrated periodically?

No: SRB,IT,P,PL

Yes: SE,ES,D,NL,B,CZ,DK,UK,SUI,SK,N,F

by who/what organisation: **ES**-Private laboratoř, **B**- a) testing equipment are calibrated by the inspection services b)testing equipment used to calibrated the testing equipment a) are calibrated by the certified ISO manufacturery, **CZ**- mostly by Czech metrological institute, and other certified persons, **DK**-Yes. It will be tested by an external company, (Force Technology) that will carry out the control of inspection companies on behalf of the Danish EPA, **F**-Workshop + GIP Pulves,**D**-plant protection service of the Federal States, **NL**- a. SKL, **N**-yes and no: the trailers are equipped with three reference manometers. The inspector can thus by himself detect if a manometer has a silure, **PL**- PIMR, **P**- by each of the inspection Centers, **SK**-accredited calibration laboratories, **SE**-but only by the operators, **SUI** - checked, but not calibrated, by Agroscope, **UK**- By independent organisations,

frequency: **ES**-In most cases yearly, **B**-a) monthly b) yearly, **CZ**-manometers and flowmeters - 2 years, checking of electronic patternators every 4 years, volumetric glassware only once, **DK**-Approximately every second year. It has not taken place yet, **F**- Depending of the aktivity-at least 1 calibration each 200 inspections and/or 2 times per year,**D**-2 years, **NL** -early, **N**-We also measure manometers. However the control of inspection equipment in use is not adequate at the moment (incomplete and to low and random freqency), **PL**-yearly or twice a year, **P**-180 days, **SK**-2 years, **SUI**-about all 5 years, **UK**- Master gauge re-calibrated annually by specialist organisations, other gauges checked against this on regular basis

how are this inspectors trained: **B**-a) within the rules of ISO 17020 b) within the rules of ISO standards, **DK**-They are obliged to take a four day course on inspection of sprayers with a test in the end. Same course for both inspectors of sprayers as the control personel. The people at Force technology carries out control of other kinds of workshops/machines and are used to control tasks, **D**-training courses, **NL**-not needed up to now, else internal training, **P**- Inspectors course organized by the DGAV and other organizations, **SK**-Slovak National Accreditation Service (SNAS), **SUI**-members of the working group "sprayer test", **UK**- Inspectors are trained by NSTS personnel and assessed by City & Guilds for Certificate of Competence in Sprayer Examining

comments: **IT**-Checking and calibration are recommended but not mandatory. Testing equipments are partially checked during periodic monitoring of the workshop, **DK**-The course has to be followed up by a one day course at the latest after 5 years. Maybe earlier - if new standards are being required used, **F**-calibration made by certified equipments (tested by officials labs), **N**-Inspected by skilled staff from NMBU

Testing location

1. question
Are the requierements for the testing location based on ?

EN13790/ISO16122 SE,SRB,IT,ES,D,NL,CZ,DK,UK,SUI,PL,F, **SK**-the test field and orchard sprayers,

different, please specify: **B**-ISO 17020, **P**-At the moment only mobile inspections are operating (stationary inspection centers are expected). The requirements for the, **N**-the system is based on 70 mobile equipped inspection trailers in order to reach out the farmers. The operator shall take part of the inspection.

additional, please specify: SE, **DK**-We have made some additional requirements/description in our guideline, **UK**-Additional requirements specified by NSTS, SK, **N**-Thus we also skill the operator and give advice & motivation, **F**-50m or 100 m away from water sources and water evaluation network, **P**-locations are defined by national law for the sprayers inspection (decree law 86/2010, 15 de Junho), **SK**-for testing air applicators and machines for seed treatment is a test device defined by the guideline TSUP MP2 / 2011, **SE**-National rules SJVFS 2008:1, **SUI**-agroscope

2. question
Is the testing location checked periodically ?

No: SRB,IT,ES,D,PL, **F**-more than 50% of inspections are made outside (farms,…) => imposibility to check every place

Yes: NL,B,CZ,DK,UK,SUI,SK

by who/what organisation: **P**-is planned, **N**-only mobile, **B**-a) each location is checked by the inspection service b) a sample is checked by BELAC c) a sample is checked by internal auditors d) a sample is checked by internal supervisors, **CZ**-Central Institute for Supervising and Testing in Agriculture, **DK**-By the external company Force Technology that will be responsible for the control of inspectors and the workshops, **NL**-SKL, **P**-The testing of the location, of the stationary inspection centres, is planned with the interval of 3 years, **SK**-authorized personnel NPPC-TSUP Rovinka, **UK**-By NSTS Auditors

frequency: **B**-Following the rules of the ISO 17020 and inspection service organisation: a) each location is checked every 3 years b) yearly c) yearly d) yearly, **CZ**-3 years, **DK**-Approximately every second year, **NL**-yearly, **SK**-3 years, **UK**-Every four years or more frequently as required

comments: **IT**-Testing location is partially checked during periodic monitoring of the workshop, **PL**-Once in the beginning by National Inspection of Plant Protection, **SE**- Depends of the type of testing location. New rules to better adopt the inspections to SUD are being prepared

Inspection workshop staff

1. question

Are there requirements for the professional skills of the workshop staff ?

No: SUI

Yes, please specify: B,SE,SRB,ES,D,NL,CZ,DK,UK,SK,P,PL,N,F

B-Following the rules of the ISO 17020 ("know how" about sprayers and agriculture, graduation/bachelor in agricultural studies), **IT**-Secondary school licence, ES-Technical engineer or similar + specific training course 40 hours, **CZ**-education and practice (at least secondary education with a school-leaving examination in a field focusing on plant health, plant protection, farming, gardening, growing hops, viticulture, forestry, agricultural or forestry machinery, or general agriculture and 3 years experience in operating and adjusting PAE, or at least secondary education with a school-leaving examination and 4 years of experience in operating and adjusting PAE), **DK**-Within each workshop at least one person has to document that they have a relevant education or document to have relevant experience. They have to pass the theoretical and practical test after the 4 day course, **F**-specific teaching and examination, **D**-subject-related training, requisite skills and knowledge and minimum experience, **NL**-experience with and knowlegde of sprayers, **N**-have to pass adapted courses for inspectors. Different course for inspection of crops sprayers and orchard sprayers, **PL**-5-day training course, **P**-The inspection course is required, **SRB**-Graduated engineer of agriculture, (Agricultural Engineering), **SK**-provides guideline TSUP MP2 / 2011, **SE**-Enough to pass the exam to become an inspector (the exam includes some moments of inspection at a sprayer), **UK**-Relevant engineering experience-particularly sprayering *equipment*

2. question

Are there requirements for a regular training of the workshop staff ?

No: CZ,PL

Yes, please specify details of the training: SE,SRB,IT,ES,D,NL,B,DK,UK,SUI,SK,P,N,F

IT-Training course (minumum 40 hours) + practical training (3 days or at least 6 sprayers inspected) + final exam (questionnaire + practical/oral), ES-40 hours mandatory course, **B**-studies (royal decrete, standards, etc), presentations and handlings (methods, equipments, organisation, quality system), on site training first as observer then as supervised beginner inspector (>1 month), final supervision on site before validation, metrological training (validation of calibration and survey tests), **D**-a four day course with a test in the end is required, **F**-5 years + re-examination, **NL**-basic 3 day training, **N**-theory and practice. Demonstration of an inspection. Wriiten exam (oral if needed), **P**-not determined yet, **SRB**-Training with the professors of Departmen of Agricultural Engineering, **SK**-provides guideline TSUP MP2 / 2011, **SE**-To inspect sprayers you need a valid certificate for the use of plant protection products and you need to be registered as inspector of sprayers, **SUI**-the whole tests are trained and discussed with the staff, **UK**-Requirement to attend NSTS Examiner Days and take part in NSTS Audit

3. question

Are there requirements for a periodical refreshing training of the workshop staff?

No: SE,SRB,CZ,SK,PL

Yes: IT,ES,D,NL,B,DK,UK,SUI,N,F

what interval: P-n.d. (yet), **IT**-not defined (it depends from region to region), **ES**-5 years, **B**- yearly, **DK**-each 5 years. Earlier if the Danish EPA will change the guideline according to new standards, **F**-12 to 15 months, **D**-2-3 years, **NL**-3 year, **N**-every five years, **SE**-Whenever called for by the Swedish board of agriculture (approx. every second year).Refresh course for the use of pesticide once every fifth year, **SUI**-mandatory assistance at training courses, **UK**-Random audit assessment

please specify details of the training: B-correction of supervision observation/evaluation, evolution of the decrete, evolution of technics, evolution of the sprayers, modernisation of the equipments, responsabilisation in the quality system, etc., **DK**-They will have practical and theoretical training at a school that has specialilsed in this issue. The same person educate all inspectors. It happens in close collaboration with the Danish EPA, **F**-audit made by GIP Pulves or COFRAC (accreditation) + specific meetings, **NL**-new devolpments in testing rules, testing equipment, spraying technique + refreshing testing skills, **N**-refreshing and renewing knowledge. Sharing experiences. Normally an inspector also have a presentation. Tips for improved inspection and how to solve typical problems, **P**-not determined yet, **SE**-Its a 4 day course to get a certificate to use ppp and another 4 day course to become an inspector, **UK**-Manufacturer training as appropriate

comments: CZ-Periodically, however, held diurnal workshops where are PAE inspectors acquainted with new developments in the field of inspection of PAE (legislation, inspection procedure, requirements for PAE, obligations sites, ..), **P**-not determined yet, **SE**-New rules to better adopt the inspections to SUD are being prepared. When in place they will most likely change many of the answers in this survey.

Testing protocol

question
Is the testing protocol based on ?

EN13790 SE,SRB,IT,ES,D,DK,UK,SUI,SK,P,PL

ISO16122 NL,UK,F, **B**-and ISO 17020,

different, please specify: SK, **CZ**-internal records of inspection workshops, **N**-we started already inspection in 1991 and thus the protocal is a little different. We also include some practical data and carrying out a check list for an annual countrol carried out by the operator himself, **SK**-for the control of air applicators and machines for seeds treatment; pattern protocol and process controls in methodology TSUP (MP2 / 2011)

additional, please specify: NL-Directive ministery of Infrastructure and Enviroment, **B**-Royal decreteof 13 march 2011 (Belgian monitor), **DK**-It has been modulated a bit to fit to the Danish guideline. And it has been integrated in an IT system, **N**-However the requirements and the testing instruction cover the EN13790 and ISO16122 plus some attachements, **UK**-STS additional requirements

comments: IT-Update of testing protocol based on ISO 16122 not yet completed, **CZ**-rated elements are identical with the EN13790, **NL**-ISO 16122 is base but adapted to specic circumstances and history, like the use of mechanical patternator, **SE**-New rules to better adopt the inspections to SUD are being prepared. When in place they will most likely change many of the answers in this survey.

Sticker

1. question
Is a sticker used on approved sprayers?

Yes: SE,SRB,IT,ES,D,NL,B,CZ,DK,UK,SUI,SK,P,PL,N,F

No:

2. question
With unique number?

Yes: B,CZ,DK,UK,SK,P,PL,SE,SRB,ES, **NL**-only unique number of the protocol, **F**-2 different stickers: one for identification (no limit of validity) one for approval of sprayer

No: IT,D,SUI,N

Test report

1. question
Is the testing protocol based on?

EN13790 SE,SRB,IT,ES,D,DK,UK, P,PL, **SK**-the test field and orchard sprayers,

ISO16122 NL,B,UK,F

different, own form: DK,UK,SUI,N,**CZ**-national regulations, rated elements are identical with the EN13790, **SK**-for testing (controls) air applicators and machines for seeds treatment, **PL**-Other equipment than covered by EN 13790,

2. question
Is the number of the sticker mentioned on the test report ?

Yes: SE,SRB,IT,ES,NL,B,CZ,DK,UK,SK,P,PL,F

No: D, SUI, **N**-no number on sticker **,**

comments: **IT**-Update of test report based on ISO 16122 not yet completed, **CZ**-numbers of stickers are alloted by Central Institute for Supervising and Testing in Agriculture, **N**-we also point out maximum nozzle output to be used on this sprayer and still remain a proper hydraulic agitation, **P**-The inspection report was done according to the EN 13 790. However the information from the software (approved by the DGAV) with the data of the measurements obtained during the inspection can be also presented to the sprayer operator, **SE**-New rules to better adopt the inspections to SUD are being prepared. When in place they will most likely change many of the answers in this surfy, **UK**-Sticker and test report form are uniquely numbered

Performed test

question
Is there a control of the quality of already inspected sprayers?

No: SE,SRB,ES,D,P

Yes: IT,NL ,B,CZ,DK,UK,SK,PL,F

by who: **N**-not ta the moment, **IT**-Local Administration,**CZ**-Central Institute for Supervising and Testing in Agriculture, **DK**-The Danish EPA has made a contract with a control company Force Technology, who will be responsible for the quality testing, **F**-GIP Pulves, **NL**-SKL, **N**-not at the moment, **PL**-National Inspection of Plant Protection inspector may recommend re-inspection in the official workshop, **SK**-phytoinspector ÚKSÚP, **UK**-NSTS Audit Procedure

frequency: IT-1-2 years (it depends from number of inspcetions made by single workshop), **DK**-They are expected to visit all inspection companies every second year, **F**-15 months, **NL**-min. yearly, **PL**-Depending on assessment in the farm (during PPP use inspection), **SK**-yearly, **UK**-Random as required

how is planned: IT-It depends from region to region, **DK**-They will be able to see in an IT system when the workshops are doing testing of sprayers and will inform them the day before about their control visit, **NL**-efficent routing, history of workshop, number of inspections per workshop, **N**-to time consuming to recheck every sprayer. Stick controls or claims from operator could be a possible solution, **PL**-Farm inspections are planned basing on the risk assessment (frequency of applications, possibility of mistakes) or interventionally, **SK**-annual plan to ensure phytocontrols, **UK**-Random selection or where there is a perceived problem/requirement

how are inspectors trained: IT-no training in planned,**CZ**-training within the organization, **DK**-Four day course as mentioned above. They have skills to control companies and mashines already. They have received advice/training from NL (Jaco Kole), **NL**-internal training, **N**-better solved by dicussing together with experiences insepectors how to carry out the tests, **PL**-General trainings system for inspectors exists (legal news, application technique, etc.). There is a demand of proffessional education and self-education of inspectors. Inspectors with long time experience are choosen to do the inspections in the farms, **UK**-NSTS Auditors hold the same Cert of Comp as sprayer inspectors

comments: CZ-inspectors of the Central Institute for Supervising and Testing in Agriculture can check basic requirements for PAE, **N**-new educated inspectors have to follow experienced insepctors up to 5 inspections before they are totally approved to test on their own, **PL**-There is a system of official workshps control (measurement equipment, documentation of inspections, etc.), **SK**-Central Controlling and Testing Institute in Agriculture (ÚKSÚP), **SE-**New rules to better adopt the inspections to SUD are being prepared. When in place they will most likely change many of the answers in this survey.

Registration

1. question
Is there a national/regional database with official workshops ?

No: SE,SRB

Yes: IT,ES,D,NL,B,CZ,DK,UK,SUI,SK,P,PL,N,F

owned/maintained by: IT-DISAFA-University of Torino and ENAMA, **ES**-Ministry of agriculture, **B**-ILVO and CRA-W are the only legal inspection services in Belgium, **CZ**-Central Institute for Supervising and Testing in Agriculture, **DK**-Owned and maintained by the Danish EPA and developed by a company in the Netherlands (Sonima), **F**-GIP Pulves => Publisher on website, **D**-plant protection service of the Federal States, **NL**-SKL, **N**-on the web page of Norwegian Food Safety Authority, **PL**-Open acces internet database maintained by National Inspection of Plant Protection, **P**-A national data base is being created by the DGAV, **SK**-NPPC-TSÚP Rovinka, **SUI**-Schweizerischer Verband für Landtechnik, **UK**-NSTS

2. question
Is there a national/regional database with all certified test operators ?

No: SRB,D,CZ

Yes: SE,IT,ES,NL,B,DK,UK,SUI,SK,P,PL,N,F

owned/maintained by: **IT**-DISAFA-University of Torino and ENAMA, **ES**-Ministry of agriculture, **B**-AFSCA is the head of ILVO and CRA-W for sprayer inspection activities, and has a free access to the ILVO's and CRA-W's databases, **CZ**-only database of the responsible persons exists, **DK**-Owned and maintained by the Danish EPA and developed by a company in the Netherlands (Sonima), **F**-GIP Pulves, **NL**-SKL, **N**-on the web page of Norwegian Food Safety Authority, **PL**-Database maintained by National Inspection of Plant Protection and each of training units (few-several?), **P**-idem, **SK**-NPPC- TSÚP Rovinka, **SUI**-Schweizerischer Verband für Landtechnik, **UK**-NSTS

3. question
Is there a national/regional database with all performed inspection of sprayers?

No: SE,SRB,IT,D,SUI

Yes: ES,NL,B,CZ,DK,UK,SK,P,PL,N,F

owned/maintained by: **CZ**-Central Institute for Supervising and Testing in Agriculture, **F**-GIP Pulves, **N**-Norwegian Food Safety Authority, **P**-the information from the inspection center needs to be sent to the DGAV, **SK**-NPPC- TSÚP Rovinka, **UK**-NSTS

comments: **IT**-NAP mentions that a nationl/regional database with all performed inspection of sprayers shall be made but, actually, only few regions have specific software. There is still not a national database, **ES**-Ministry of agriculture, **B**-ILVO and CRA-W manage their own database of sprayers, **CZ**-electronic database, which is filled by inspection workshops, **DK**-Owned and maintained by the Danish EPA and developed by a company in the Netherlands (Sonima), **F**-These 3 database are grouped in one single and complete tool. Specific access for administrators, inspectors, teaching centers, official bodies but not for public, **NL**-SKL, **N**-however we struggle to get all the inspection sent in to this authority, especially now when the inspections not are subsidized (was unntil 2005), **PL**-Database maintained by National Inspection of Plant Protection, generally for internal use, **P**-Besides the general data base that is being done by the Ministry of the Agriculture, the inspection centers have already created a personal data base with the results of the inspection, **SE**-New rules to better adopt the inspections to SUD are being prepared. When in place they will most likely change many of the answers in this surfy, **UK**-Access to data is available to crop assurance certification bodies for confirmation purposes.

Conclusions from the survey

Most answered countries have some kind of quality assurance systems but big differences between the submitted answers are still obvious.

Quality assurance is an important matter and need seriously to be harmonized.

Guidelines for certifying workshops are needed.

The information (see above) was obtained from received surveys from the MS. The information does not linguistically modified.

Quality assurance as a key point in effective sprayer inspection schemes.

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1. Introduction

When introducing an inspection scheme for the periodical inspection of sprayers in use, important for the effectiveness of this system and for the support of this inspections amongst the farmers, is the quality and uniformity of the performed inspections. The inspection scheme needs to have checks and balances in order to create this quality and uniformity.

The base of the inspections are the requirements in the European Directive 2009/128 article 8 and Annex 2. This requirements in Annex 2 are for the most common sprayer types in detail specified in the harmonized standards of the EN-ISO 16122 series for the different types of sprayers. The inspections have to be executed by inspectors who are well trained in how to use this standards and from who the knowledge is also kept up to date by means of periodical refreshing courses. The measuring equipment used during the inspections has to be accurate, in line with the harmonized standards, but it must ensured that during time, the accuracy and condition of the testing equipment stays on an acceptable level.

To keep the quality of the performed inspections good and the output uniform, a system of quality assurance is needed. This system also has to include elements of quality control, both on the performed inspections as on the testing equipment.

For a good mutual recognition of performed inspections between the different member states in the EU, a uniform basic system of quality assurance in all member states is needed.

This system will include elements like training of the inspectors, requirements of the workshop facilities, inspection procedure, quality control on the performed inspections, calibration of testing equipment, registration of the performed inspections and a procedure about how to deal with non-conformities.

The basic elements of such a quality assurance scheme needs to be implemented through all European countries in order to reach a working system of mutual recognition and a meaningful output of the effort to establish a system of periodical inspection of all sprayers in use with support of the users of sprayers.

2. Inspection Scheme

How the inspection scheme is organized can difference from country to country and depends on specific demands, history, national legislation and polity. But most general is organisation where national body is responsable for the correct organisation and supervision and recognized workshops who inspect the sprayers of the farmers.

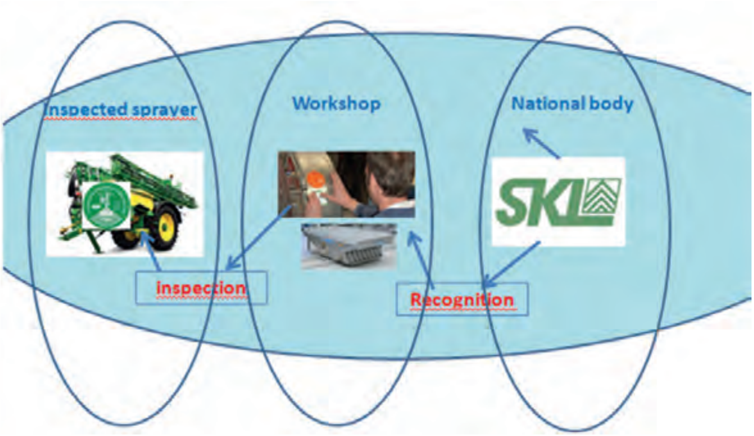


Fig. 1. Example of a sprayer inspection scheme.

3. Quality Assurance Scheme

a. General

To guarantee the quality and uniformity of the inspected sprayers a Quality Management System is needed, what will cover all aspects and processes of the complete inspection scheme. From the development of criteria to the inspection them self, including the test report and sticker on the machine.

This guideline is not meant to develop a QMS ready for certification for ISO9001 or ISO17020, but is meant to create a QMS to perform the inspections in a right and uniform way. But the general principles of this management systems are included in this guideline.

A general figure for the layout of a QMS system bases on ISO9001 is:

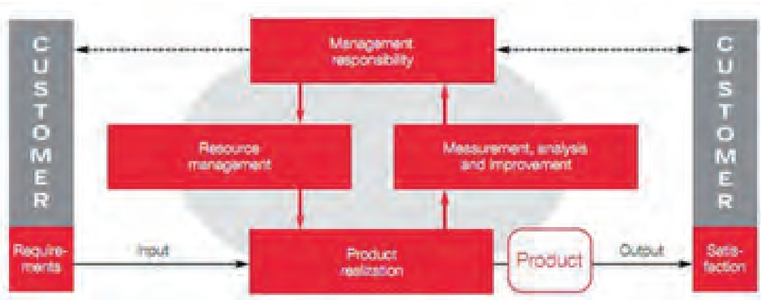


Fig. 2. Typical layout of system acc. to ISO9001.

When this layout is adapted to a sprayer inspection scheme it will be like this:

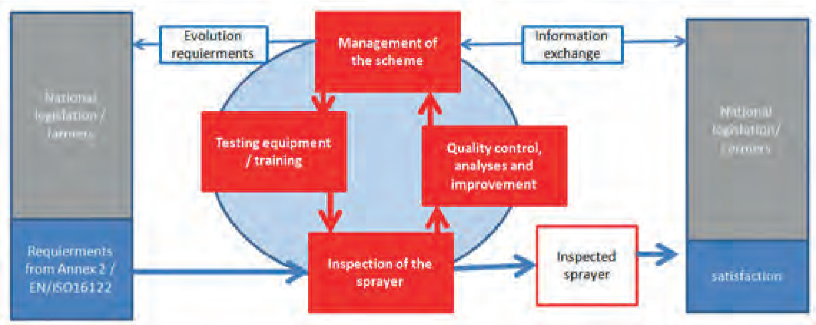


Fig. 3. General layout sprayer inspection scheme.

Where the input is:

- the national implementation of the demands from Article 8 from the EU directive 2009/128/EC (i.e. frequency, types of sprayers what have to be tested, etc.)
- the requirements what are in Annex 2 of 2009/128/EC: Health and safety and environmental requirements relating to the inspection of pesticide application equipment. And for sprayer types where harmonized standards are developed for, the standard EN-ISO 16122.
- Specific national/regional demands, like national legislation, specific demands, specific organisational structures what are already available.

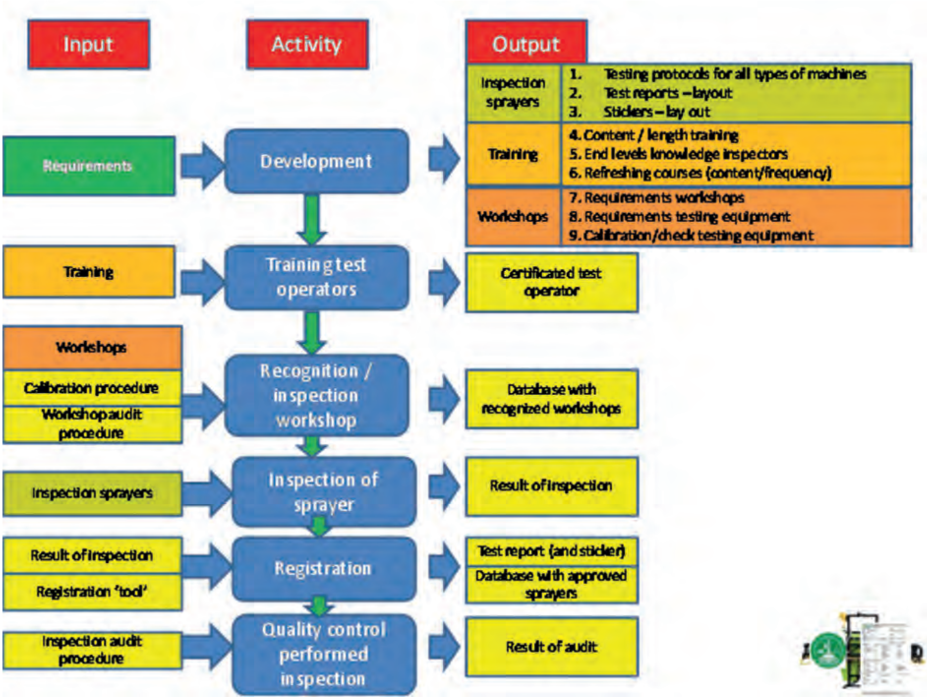
The output is:

- Inspected and approved sprayer according to the guidelines complete with test report and sticker.

Important is that the QMS is shaped according to the well known Plan-Do-Act circle, that the system is developed for a continuous improving of all elements, procedures and documents.

This means that the feedback from workshops, authorities, inspectors and farmers will be used as input for this improvement.

Outline of the total inspection scheme:



In the following paragraphs the activities, documents and procedures will be described.

b. QMS: Activities

In the Quality Management System (QMS) the following activities are present:

Management/development documents and procedures

The objective of this activity is to manage the system, to develop and maintain the procedures and to develop and maintain the guidelines gathered around 3 theme's:

1. Inspection of sprayers
    a. Testing protocols for all types of sprayers
    b. Test –report (content / layout)
    c. Sticker (content / layout)
2. Training of the inspectors
    a. Content and length of the training
    b. Definition of the entrance level and the end level the trainees have to reach.
    c. Refreshing courses (frequency / content)

3. Requirements workshops

    a. Requirements workshops
    b. Requirements testing equipment
    c. Calibration/check testing equipment

b. Training of the test-operators

The aim of this activity is a proper training of the test operators. Important is that they have enough skill to perform the inspections in line with the formulated testing protocols, give the correct interpretation of the measuring results of the testing equipment, give the owner of the sprayer a clear advice and fill in the test report in the right way.

Therefore a basic trainings course with both clear entrance – and end levels is needed. To keep the knowledge and skills of the test operators periodical refreshing courses are needed.

c. Recognition and inspection of the workshops

The aim of this activity is to establish and maintain only workshops who full fill the defined requirements, have the correct, calibrated and maintained testing equipment. The process includes an initial and periodical audits of the workshop.

d. Registration of the performed inspections

The activity of registration of the results of the inspections includes the issuing of the test reports. In article 8.6 of 2009/128/EC is stated that the national organisation issues the certificates of approved sprayers. But this registration system is also needed to create an overview of the issued certificates to inform the European Commission. The statistical information gathered from the test reports can also be used to both improve the inspection scheme and inform the users of sprayers.

e. Inspection of the sprayers

This activity is the end process of the other activity. A trained test operator at a recognized workshop (which includes well calibrated testing equipment) inspect the sprayer following the guidelines and register the results of the inspection in the right manner.

f. Quality control of the inspected sprayers

The keep the quality uniform, audits of the result of the inspections (i.e. inspected sprayers) are needed. The results of this audits can used both for improvement of the system and for the recognition of the workshop.

c. QMS: documents

As input for the other activities in the first activity some basic documents have to developed. But not only developed, they have to be maintained, following the Continuous Improvement circle. Input can come from different sources: from participants in the inspections scheme, from audits, from owners of sprayers or from developments in national or international legislation or standardisation.

The different documents are:

1. Inspection of sprayers

a. Testing protocols for all types of sprayers

For all relevant types of sprayer specific testing protocols have to be developed. This protocol can be based on harmonized standards (like EN-ISO 16122) or Annex 2 of 2009/128/EC combined with elements from harmonized standards for types of sprayers no harmonized standard is available.

b. Test –report (content / layout)

Based on EN-ISO 16122:1 the test report shall contain at minimum the following information:

- Recognized workshop / test team what executed the inspection;
- Reference to EN ISO 16122 and deviations, if any;
- Owner's identity;
- Owner's address;
- Sprayer manufacturer;
- Type of sprayer;
- Serial number or other unique identification;
- Year of construction;
- Drive (i.e. Mounted/trailed /self-propelled);
- Name and contact details of the inspector and where different the testing organization and Signature;
- Date of inspection;
- Any malfunction of the sprayer. If the malfunction is a result of sprayer design this should be noted;
- Any information on malfunctions of the sprayer useful to identify the corrective work required;
- Results of measurements.

c. Sticker (content / layout)

By means of the content of the sticker it shall be clear for the owner of the sprayer:

- Reference to national body
- Date of expiring
- Preferably a unique number

2. Training of the inspectors

Content and length of the training

Central in the course shall be how to implement the testing protocols for the different types of sprayers and how to use the testing equipment and interpreting the measuring results. Extended by knowledge about the testing scheme and legislation. Dependent on the entrance level it can be extended by knowledge of sprayers/spraying technique or it can be extended with knowledge about calibration/adjustment of sprayers.

Definition of the entrance level and the end level the trainees have to reach.

Important is that there are entrance levels for the participants of the courses. General knowledge about and practical skills with sprayers, spraying technique and nozzle should be known.

The end level to trainees shall reach shall be clear defined and tested by means of a clear theoretical and practical examination.

Refreshing courses (frequency / content)

To keep the level of the test operators up to date, refreshing courses with a reasonable interval are important. The content should focus on new developments and new techniques but also a rehearsal of the testing protocols.

3. Requirements workshops

a. Requirements workshops

The requirements the workshops have to meet shall be clear defined:

- Type, size and focus of the enterprise
- Number of test operators
- Test location (safe and environmentally friendly testing)

b. Requirements testing equipment

The requirements for the testing equipment are mostly defined in relevant parts of the standard EN-ISO 16122. Important to define is if a type approval in needed, how to deal with testing equipment what is already certified in another Member State, how to deal with homemade testing equipment.

c. Calibration/check testing equipment

Important for good inspections is accurate testing equipment, therefore periodical calibration/check of the testing equipment is needed.

In EN-ISO 16122 for some testing equipment the minimum intervals are defined, for the other testing equipment the interval shall be defined.

This calibration can be done by independent organizations / laboratories following the calibration procedure.

d. QMS: procedures

The following procedures are needed:

1. Development of documents

Input of this procedure are the requirements as defined in 4.1 General. The output are the documents. This is a continuous process fed by input from sources like results from audits workshops and inspected sprayers, developments in legislation, standardisation, spraying technique and testing equipment.

2. Training of test operators

Input of this procedure are the documents with the demands for the content and end-levels of the training. Result shall be certified test operators.

3. Registration of certified test operator

The certified test operators shall be registered in a central database in a uniform way. This information is used both for the recognition of workshops and for the registration of results of the inspections.

4. Recognition of a workshop

Workshops shall be recognized following the demands for the workshops, the testing equipment and the outcome of the audit procedure.

5. Workshop audit procedure

Workshops shall be initial and periodical audited following the demands for the workshops and testing equipment.

6. Calibration of testing equipment

Testing equipment shall be periodical calibrated or checked on correct and accurate operation. This calibration can be done by independent laboratories, the official organisation or other to be defined organisation. Important is to describe the asked accuracy of reference methods / instruments used to the calibration.

7. Registration of recognized workshops

The recognized workshops shall be registered in a central database, this list of workshops shall be visible for the owners of sprayers.

8. Inspection of sprayers

Sprayers shall be inspected by recognized workshops by certified test operators following the relevant testing protocol. The results of the inspection shall put on a test report. Only sprayers what meet all requirements shall be approved.

9. Registration of the results of an inspection

The results of an inspection shall be registered in a uniform way on the defined test report. This test reports shall be stored in a database where the results can be analysed.

10. Administrative process how to distribute stickers

Only recognized workshops can use the stickers. It has to clear that no misuse is possible and what workshop used what sticker on what sprayer.

11. Inspection audit procedure

Periodical audits of the process the test operator is following when testing a sprayer or the result of this inspection (the tested and approved (or disapproved) sprayer) are needed in order the keep the quality uniform. The output of this procedure will be used in the procedure of recognizement of the workshops.

4. Conclusion.

The requirements for the sprayers in Annex 2 of the EU directive 2009/128/ec and the harmonized standards of the EN-ISO 16122 series are a good base for testing sprayers in the EU. But to have within a member state and between member states uniform inspections of a high level of quality, which is needed to reach enough support among the owners of sprayers and for an effective mutual recognition, a system of Quality Assurance is needed. This paper gives an outline and base of a future SPISE Advice on this topic. It is based on the harmonized EN-ISO standards and includes other SPISE advises on the different topics.

ENAMA "Certification" of the inspection workshop activity: the necessary requirements

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Summary

In European Directive 128/2009/EC it is stated that "each Member State shall establish certificate systems designed to allow the verification of sprayers inspections", but no further indications are provided on how to make such certifications. In Italy the ENAMA (National Board for Agricultural Mechanization) working group – established to co-ordinate the sprayers inspection activities at national level – has prepared a specific document containing the guidelines on how to get, on a voluntary basis, an ENAMA certification which attests the conformity of test equipment and of test procedures adopted in the inspection workshops. In this document directions are reported on how to assess the conformity of the inspection workshops to a set of listed requirements, referred either to other ENAMA documents, or to the National Action Plan, or to ISO/IEC 17020.

The ENAMA certification of conformity therefore represents an added value for the sprayers inspection and calibrations Workshops as it ensures, through periodical inspections, that workshops apply the correct administrative (e.g. management of data and record of test reports) and technical procedures in their inspection activity and that they use appropriate test equipment and instruments.

In this paper the requirements needed to get and to maintain over time the ENAMA certification of conformity are described.

Introduction

European Directive 2009/128/EC (Art. 8) requires that "Each Member State shall establish certificate systems designed to allow the verification of inspections and recognize the certificates granted in other Member States", but no further indications are provided on how to make such certifications.

Following the Directive 128, Italian NAP (National Action Plan) requires that "Inspection Workshops shall be equipped with suitable equipment for carrying out inspection activity and shall ensure that no environmental pollution is produced during test".

In Italy the ENAMA (National Board for Agricultural Mechanization) Working Group has defined guidelines on how to get, on a voluntary basis, an ENAMA certification which attests the conformity of test equipment and of test procedures adopted in the inspection Workshops. Main topics examined in the Enama guidelines are:

1. Minimal characteristics of the workshops facilities;
2. Minimal characteristics of the workshops test equipment and instruments;
3. Procedures for data management data transmission and burocracy.

To realize this document Italian NAP and International Standard ISO/IEC 17020 was taken principally as reference. In details, the parts of the ISO/IEC 17020 Standard concerning the administrative requirements, the data and inspection results management (privacy policies), the quality of inspection activity, the equipment used, the inspection methods and the recording of inspection/calibration results (test reports and inspection certificates) related to workshops were taken into account.

This kind of voluntary certification is therefore an added value for workshop that already have the official authorization to make sprayers inspection/calibration.

Workshops officially authorized to make sprayers inspection/calibration that ask for the ENAMA certification must provide ENAMA with a set of documents concerning their activity, structures, technical personnel and equipment used to inspect sprayers. The following documents have to be attached to the request form for the ENAMA certification:

- names and licenses of the technicians who make sprayers inspection in the workshop;
- declaration in which the workshop agrees to transfer the results of sprayers inspection/calibrations to the reference board (e.g. Regional office of agriculture) at regular intervals, by internet and ad hoc software;
- declaration in which the workshop agrees to allow his licensed technicians to attend the periodical refreshment courses organized by the local/national Administration;
- declaration in which the workshop confirms that the inspection/calibration activity carried out is complying with the impartiality principles and privacy policies.

Minimal characteristics of the Workshops facilities

Workshops (fixed or mobile) officially authorized by local administration to make sprayers inspection and calibrations must be equipped with adequate protection from the influences of weather (wind and rain) of the place in which are carried out sprayer inspection/calibration activities. In particular, "fixed" workshops shall be equipped with a shed or a specific "test area"

Fig. 1. Examples of fixed and mobile Workshops.

"Mobile" Workshops shall also be equipped with protective structures (protective cover or mobile hangar) against the influences of environmental factors or, alternatively, shall be able to record, with adequate instruments, atmospheric data that may affect the proper performance of inspection.

Fig. 2. Example of test area of fixed workshop.

Fig. 3. Mobile hangar.

Workshops that inspect field crop sprayers shall be able to ensure that the place where the inspection/calibration is carried out is large enough to accommodate a proper verification of distribution uniformity of the boom throughout its full length.

All Workshops shall have a flat area equipped with a suitable system for collection and disposal of liquid sprayed during inspection/calibration and with structures able to ensure that there are no leaks of polluting residues generated by sprayer inspected/calibrated.

Fig. 4. Place where the inspection/calibration is carried out shall be large enough to accommodate a proper verification of distribution uniformity of the boom throughout its full length.

Fig. 5. Examples of systems for collection and disposal of liquid sprayed and for ensuring that there are no leaks of polluting residues generated by the sprayer.

During and after inspection/calibration, it shall be possible to clean the equipment and test benches used and it shall be possible to collect and properly dispose of all wastes produced.

If inspection/ calibration is made indoor, a system to properly recover tractor or self propelled sprayers exhaust gases shall be available.

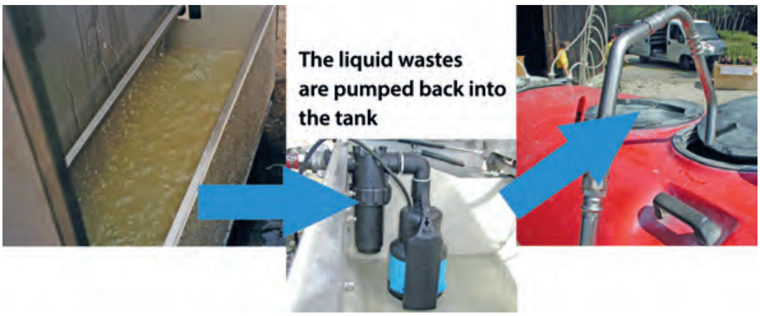

Fig. 6. Example of system for collection and properly disposal of all wastes produced during sprayer inspection/ calibration.

Minimal characteristics of the workshops test equipment and instruments

All equipment used for sprayers inspection/calibration must follow ISO FDIS 16122 2-3 requirements and be provided (or better "certified") with an official documentation issued by an official Board. For example, **Analogue pressure indicators** used for verification shall have a minimum diameter of 100 mm. Other minimum requirements on pressure indicators used for verification are given in Table 1.

Pressure to measure Δp bar	**Scale unit max.** bar	**Accuracy** bar	**Class required**	**Scale end value** bar
0< Δp≤6	0,1	0,1	1,6	6
			1,0	10
			0,6	16
6< Δp≤16	0,2	0,25	1,6	16
			1,0	25
	1,0	1,0	2,5	40
			1,6	60
			1,0	100
1 bar = 0,1 MPa = 0,1 N/mm^2 = 10^5 N/m^2				

Tab. 1. Characteristics of pressure indicators used for verification (values in accordance with EN 837-1).

Concerning **test equipment for pump capacity test**, the error of the flow meter shall not exceed ± 2 % of the measured value when the capacity of the pump is > 100 l/min and 2 l/min when the capacity of the pump is < 100 l/min. The flow measuring device shall have a transparent part to identify air leakages on the pump's suction side and the test equipment shall have a provision that the pressure can be increased up to 10 bar.

Horizontal patternator shall have grooves 100 mm wide and at least 80 mm deep, measured as a distance between the top and the bottom of the groove, shall be used to measure the uniformity of the transverse volume distribution of the spray. The groove patternator shall be at least 1,5 m long. The groove width shall be 100 mm ± 2,5 mm. The groove width of a patternator working in steps with electronic data sampling (e.g. scanners) shall be 100 mm ± 1 mm. The graduated spray liquid measuring cylinders shall be of the same type and size and have a capacity of at least 500 ml. Scale graduation shall be a maximum of 10 ml. The error of measurement shall not be more than 10 ml or ± 2 % of the measured value whichever is greater. When passing the measuring track, positioning in single steps shall be completed with an accuracy of ± 20 mm. The measuring error of the volume of the single grooves at a flow volume of 300 ml/min shall be less than ± 4 %.

In this respect, it is recalled that in Italy during 2013 was issued the first certificate ENAMA/ENTAM of an horizontal patternator (www.enama.it/certificati/enama_cer_90-001_en.pdf).

Equipment used to carry out inspection/calibration shall be periodically (e.g. every two years) subjected to controls to provide their functionality. Reference instruments (pressure gauge, flowmeter, balances…) shall be calibrated by competent national bodies (e.g. for Italy - https:// www.accredia.it/context.jsp?ID_LINK=750&area=7).

Fig. 7. ENTAM test report of a horizontal patternator.

Concerning **vertical patternator**, no indications are available in ISO Standard. In Italy, ENAMA technical workgroup has defined following minimal technical characteristics:

1. Size of each single collector (in case of test benches having discrete elements) ≥180x220 mm;
2. It shall be possible to collect the sprayed liquid along the whole height of the spray plume without any interruption. Vertical distance between two adjacent collectors shall be ≤300 mm;
3. Reproducibility of measurements: CV ≤10%, determined after 4 test replicates and referred to the complete vertical spray pattern obtained through the amount of liquid collected in the graduated cylinders which shall have a capacity ≥50 ml and content scale ≤1% of their capacity.

Procedures for data management, data transmission and burocracy

All work carried out by certified Workshop shall be documented. These documents shall be contain both inspection/calibration results, both information required to understand and interpret them.

Results of functional inspection/calibration shall be sent to ENAMA (or other board indicated by ENAMA) at the end of each control or within 15 days. In case of delay or non-delivery, Workshop shall provide written reasons to ENAMA.

Workshops that have the ENAMA certification are subjected to checks that are carried out systematically every two years by an organization nominated by ENAMA:

- control of the validity of the official license for sprayers inspections and its registration in the national database
- correct application of the test methods for sprayers inspections reported in the ENAMA documents

- management of data collected during the sprayers inspection using the appropriate official forms
- correct storage of the documents on informatics support
- efficiency of the equipment used to make the sprayers inspections.

Both workshops and licensed technicians are checked either during the inspections or afterwards on the already inspected sprayers; in this latter case it is checked the exactness of the inspection results reported in the official documentation.

More attention however will be focused on equipment and instruments used for the inspections, examining the documents related to their calibration and functionality.

ENAMA workshop certification has a four-year validity. Within three months after the end of the four years period, the workshop may request a renewal. When the workshop is not more suited, ENAMA can withdraw the certification or can reject the request for renewal. The withdrawal of the ENAMA certification is automatic if the workshop official authorization (at Regional level) to make sprayers inspections is suspended or withdrawn for any reason.

Workshop shall have a documented procedure concerning modes of behavior in case of complaints received in relation to functional control activity or its results.

Workshop and its staff shall ensure their independence of judgment and integrity in relation to their activities and ensure the confidentiality of information obtained during inspection/calibration activity.

Final considerations

Workshop certification of conformity means certainly an added value for the sprayers inspection Workshops because it ensures that Workshops apply the correct administrative (e.g. management of data and record of test reports) and technical procedures in their inspection activities and that they use appropriate test equipment.

Workshop Certification of conformity is believed to be essential for Workshop activities mutual recognition and ENAMA guidelines could be a first reference document to define SPISE advices on how to make Workshop Certification of conformity.

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Consequences of including inspection of sprayers in use in the new Regulation on official controls

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The Swedish Board of agriculture does not support the proposal from the Commission to include inspection of sprayers in the Regulation on official controls[1]. Unfortunately the proposal creates many obstacles regarding our current work to produce a new mandatory system of inspections (according to article 8 of the **Sustainable Use Directive** 2009/128/EC (**SUD**)) on the basis of the existing voluntary system.

1 Summary

- Inspection of sprayers in use in its current form cannot be carried out under the control regulation because:
  - Neither size of sprayer inspections nor the use of pesticides is large enough to support the administrative structure of the regulation of official controls. Too high costs need to be transferred to the customer.
  - It is unclear if the control regulation allows free pricing.
  - The fee for an inspection of sprayers in use regulated by the control regulation would affect the number of sprayers and thereby diminish the market
  - The possibilities to implement inspection of sprayers in use outside a workshop decreases. The demand that inspections should be free from any conflicts of interest may make repairs and advisory services impossible
  - The control regulation does not provide any guidance as to how inspection of sprayers in use should be done in practice. The administrative control adds no positive value to the business. Planned improvements in quality assurance will be impossible
- This official proposal creates difficulties to give straight answers to companies that want to expand their business. Since an expansion is necessary to provide access to inspections for all plant protection users, straight answers is crucial to implement mandatory inspections.
- If inspection of sprayers, despite our arguments, should be included in the regulation on official controls, the decision should be based on an impact assessment including a cost-benefit analysis, and whether there are alternative ways to achieve the benefits. Our assessment is that the cost of the regulation for corporate profitability, the environment and working conditions for all personal and, above all, increased administration at all stages is not offset by improvements.

1 COM (2013) 265 final

2 Background

Due to the requirements in the SUD that all equipment for the dissemination of plant protection products should be inspected at least once, not later than 26 November 2016, the Swedish Board of agriculture has presented a proposals for how today's optional inspections (that have existed since 1988) could serve as a basis for a new compulsory activities. The Swedish government has proposed that Sweden implement the proposal and that the existing voluntary inspection system should be transformed in to a mandatory system.

In the review of the Regulation 882/2004 of official controls, it is proposed that the SUD should be included in the official controls. Specifically, under article 159 the article 8 of the SUD is amended and instead the Commission is empowered to adopt delegated acts. Member states should even so be obliged to follow the SUD until these delegated acts is adopted. **This document attempts to describe the impact on inspections of sprayers in use if the inspections are made under the regulation instead of the SUD.** In the parts which depends on what the Commission chooses to include in the delegated acts the analysis, by necessity, becomes a little speculative.

3 The Swedish inspection system of today

There has been no need to redo the inspection system from scratch in order to adapt them to the SUD. There has been a high confidence for the inspections, especially in those parts of the country where the inspections has been most frequent. The number of boom sprayers is estimated to be just over 14,000. In an interview-survey, respondents indicated how often they inspected their sprayers. The percentage of sprayers that was inspected as recommended, each or every other year increased from 35% to over 50% between 1998 and 2006. Some sprayers were inspected on a regular basis but with three years or longer intervals, and for some there was no information given. That indicates that more and more sprayers are tested regularly, even if the inspections are optional.

Sweden has invested a lot in the sprayer inspection system. Throughout the years we have trained many inspectors, of which approx. 100 are active today. The inspectors have also been granted aid to test equipment. Since 2006, subsidies have been granted for the purchase of about seventy test equipment. But some more supported equipment is in use because purchase of equipment was also supported prior to 2006. The equipment now belongs to the inspection companies and is used in the business and for many companies it is an essential part of their rural entrepreneurship.

Today, a typical Swedish inspection business is carried out on a part-time basis during some parts of the year by small business owners who typically have farms, mechanical workshops or less engineering activities as their main occupation. Inspections are carried out either on farms or in workshops.

An inspection contains the following elements:

- Technical control of the sprayer according to the standard EN 13790 and some additional national requirements
- Repairs and adjustments of faults and shortcomings
- Information and advice to the operator. An important element here is the calibration of the sprayer.

The Swedish inspections have according to the spray owners led to:

- A safer working environment for the operator
- Less risk to the external environment
- Better placed for adequate effect of treatment with the lowest possible dose
- Greater operational safety.

All in all, Inspection of sprayers in addition to environmental and safety benefits, lead to a more efficient and economical food production.

If inspection of sprayers result in a well maintained and calibrated sprayer that give the operator a possibility to reduce the dose, then inspection may become a tool to reduce the use of chemicals and to lower residues on the products. However for food safety, the choices of plant protection product have a greater significance for residues than the spray pattern.

4 Difficulties to conduct today's inspections under the control regulation

Today for most Inspections companies the inspections is a form of complementary business activities in rural areas.

If the Inspection is going to be done under the regulation the whole concept has to be reevaluated and changed accordingly. The reason for this will be discussed below.

4.1 The size of spray inspection and the use of plant protection products is not adapted to the administrative superstructure of the regulation

In connection with an investigation about how to introduce compulsory inspections we also investigated how to insure the quality of the inspections. One option was to require accreditation of the inspections, according to EN/ISO 17020. To reach a limit where the cost of accreditation would constitute less than 10% of the total price of an inspection, at least 50-60 sprayers per year was required to be inspected. The average Swedish workshop inspects 67 sprayers per year. Since then, the estimated price of an accreditation has risen to more than the double, which means that the number of sprayers that need to be inspected in order to keep the quality assurance's share of the total cost down also needs to increase. If the operation should be incorporated in the control regulation, accreditation would be a general requirement under article 26.

Because of the "superstructure" required under the regulation, the cost for a control of the workshops do not only consists cost caused by article 26, the price for an inspection have to be increased considerably beyond what is required only for the accreditation.

The inspectors are negative to a quality assurance through accreditation as the cost of accreditation for their limited operations is too high to be able to be passed on to the customer. Moreover, they fear that the administrative burden in the inspection companies rises.

In some other cases where open system for control has been introduced and the cost for accreditation has been too high, the result has been that operations have ceased and the accredited inspection bodies were completely lacking. The authorities has been forced take over the control them self, with increased expenses as a result.

4.2 Provides the control regulation the possibility of free pricing?

It is not entirely clear whether SUD forms part of the control regulation in chapter IV (articles 75-82), the financing of official controls. If so, the model with inspectors as free entrepreneurs who put the price on what they deliver does not work.

4.3 The fee for an inspection under the control regulation decrease the number of sprayers and thereby shrinking the market for inspection

There is a limit of how much an increasing size of the sprayers is a benefit in the plan protection work. A large sprayer that have high usage during the season and used over large areas, cannot be used as optimal since the timing of the treatment is harder.

The increase in costs resulting from increasing price/inspection fees will mean that the number of sprayers falls. This will happen as a result of the transition to mandatory inspections, but become even greater if the control should be carried out in accordance with the control regulation.

Less optimal conditions during treatments will have negative effects for the environment and for the business. Fewer and sparser localized sprayers also give a smaller economic base for the workshops.

4.4 The possibilities to implement inspections outside the workshop are adversely affected

Conditions in some parts of Sweden are not entirely different from the ones in Central Europe, but differ significantly from other parts of the country. In the Netherlands (41 526 km ^{2}), there are approximately 20,000 boom sprayers and in Denmark (43 094 km^2) even more, giving a "density of sprayers" of about 1 sprayer on two 2 km ^{2}. In Scania (10 939 km^2), in southern Sweden, we estimate the number of sprayers to be just over 3400. The "density of sprayers", 1 at 3 km^2, is close to the one in Denmark and the Netherlands. In the county Jämtland (49 443 km^2) we estimated the number of sprayers to 39 and in Norrbotten, 98 911 km ^{2} there is 42 sprayers. The "density of sprayers" is thus 1 sprayer of 2355 km^2 in Norrbotten.

In the work with the European standards for inspection of sprayers EN 13790 part 1, there has been different opinions about how to measure the performance of the sprayer. Currently, there are two methods allowed. This is appreciated by Sweden since there is a difference in mobility between the different methods. The method where the spray pattern is measured along the boom is not so mobile and easier to perform in a Workshop. Although there are advantages to measure the spray pattern along the entire boom, we also need techniques with equipment that can be moved to the sprayer.

If, in a delegated act in accordance with the regulation, the Commission decides that the inspections should be performed with a less mobile scanner along the entire boom, the effects will be different and probably more sever for a Northern spray owner than for a spray owner from Scania.

In many countries, there is a desire to execute control independently of the repairs and advisory services. The idea is that the inspectors shall not be tempted to require costly repairs that they will profit on before approving the sprayer. This corresponds well with paragraph 1b of article 4 of the control regulation which requires that those who perform the checks should be free from any conflicts of interest.

However, for entrepreneurship in parts of Sweden where there is a longer distance between the sprayers than in the major agricultural counties, the consequences will be severe. Assume that there is only one inspector in a county, which is not an unreasonable assumption. Then he could have around 100 miles to go in order to inspect a sprayer. Transportation becomes a large part of the test cost. Assume that he finds a hose that needs to be replaced. Following the regulation he then has to go home and come back another day after a repairman has done the same trip. To cover the whole area of expertise for an inspector, maybe there is also a need for another person, an adviser, to make the same trip. If it is the sprayer that needs to be transported to the inspection, the consequences for the spray owner are even bigger. Transport costs are already a vast reason why the Swedish inspections are quite expensive compared to other European countries.

So it is probably a benefit also for the owner of the sprayer that an inspection also includes advices and repairs.

4.5 The Regulation on official controls does not provide any guidance as to how the inspections should be done in practice.

We know that the inspections carried out improve the quality of the sprayers being inspected. On the other hand, we have no control of the quality of the inspections carried out. We know, therefore, that the inspectors find and detect errors, but we do not know if they find all errors, or if their estimates are consistent with each other. It cannot be shown that all inspections are carried out in a uniform manner by all the inspectors. This is a source of irritation among some Inspectors because they feel that competitors may keep lower fees because they are not doing a proper inspection. We believe that in a mandatory system a basic quality and uniformity of the inspections would be welcomed by the majority of both inspectors and customers.

But the quality insurance of the inspectors according to the Regulation on official controls is very much into checking checklists. The need for instructions and someone to discuss different solutions is something that is not dealt with.

5 Other possible consequences

5.1 Risk of delay in the introduction of obligatory inspection

There is a risk that the Commission's interpretation of what to include in an inspection and included in a delegated act take considerable time to decide. Therefore there might be a risk that the imposition of mandatory inspections in Europe will be delayed because there will be a reluctance to invest in and establish the inspection system based on article 8 of the SUD, which can be revoked at any time by a delegated Act.

The voluntary inspection system in Sweden has rested on an uncertain legal basis over an extended period of time. It has made the recruitment of Inspectors and the necessary investments in equipment more difficult. The SUD gives an opportunity to correct this. The fact that the inspection of sprayers is included in the proposal for control regulation can increase uncertainty and degrade these opportunities. As long as the uncertainty about the control regulation will apply, it is more difficult to motivate new inspectors to invest.

5.2. Possible benefits of having a single control for inspection

The obvious benefit of having a common framework for the inspection of sprayers in use is that trade with plant protection services is made easier. This is already taking place in parts of Europe. For Sweden, these services have so far been of a very small scale. But the reason for this is probably geographical and not administrative.

Inspections of accredited workshops: Some Italian experiences

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Abstract

Among the activities established by the Directive 128/09 and by NAP (National Action Plan), a periodical inspection by authorities is addressed to official workshops in charge of sprayer inspections.

In this paper we describe activities carried out by two Italian regions (Umbria and Campania) that have recently started a regular activity for the inspection of workshops. An inspection procedure according to technical national guidelines (ENAMA documents) was prepared in collaboration with regional authorities and CRA-ING, that is in charge of technical aspects of inspections. The approach, the key elements and some results of inspections are reported in the paper.

Introduction

In Italy, according to the legislative decree n°150 of 2012, the National Action Plan (NAP) establishes the procedures and the methods of the Directive 128/09 fulfillment. The section of the NAP related to the periodical inspections of the sprayers (according to the article 8 of the Directive 128/09) is largely based on the ENAMA documents, that are national technical guidelines drawn up in recent years by a technical working group. The working group, coordinated by the University of Turin, is composed by experts coming from each Italian region, from universities, from research institutions and from ministry of agriculture. This group, thanks to the coordinator work, is in permanent contact with the analogous technical working groups operating in the ambit of Spise.

The point A.3.9. of the NAP states that the regional Administration (that are responsible for the actuation of the Directive in Italy) shall realize an inspection each 24 months in the workshops that make less than 200 inspections a year and each 12 months for those that make more than 200 inspections a year.

The regions Campania and Umbria have started an official activity in the last years. In 2009 was recognized the first official workshop in Campania, while the first official workshop in Umbria has started two years later. In the meantime, these two regions have gone with CRA-ING a collaborative project about the implementation of common procedures, according to the national guidelines. CRA-ING supports the regions mainly in the training of technicians, in the authorizations of new workshops and in the inspection of operating workshops.

Regarding the last point, a procedure of inspection was established in cooperation between the responsible regional offices and CRA-ING. This paper focuses on this point of the work.

Inspection points

In the inspection procedure, the following five areas of activity were identified:

1) Equipment and instruments;

2) Maintenance, conservation and transmission of inspection documents;

3) Inspection procedure (in progress);

4) Inspection procedure (follow up)

5) Technician legal requirements.

1) Equipment and instruments.

The control is addressed to verify the presence, the working condition and the maintenance state of each instruments employed in the inspection procedure. For some instruments, namely the pressure gauges employed to check the sprayer's pressure gauge and the gauges for measuring pressure drop, a function test was also carried out. This test has no validity as a calibration test, but it can be just considered as a second level check of the instrument's precision made with a second certified pressure gauge; for this check, no threshold levels of required precision are requested.

Fig. 1. The function test of a pressure gauge.

The other equipment to check, in terms of existence and state of maintenance, include: test bench for control of nozzle flow rate; test bench for pressure control; any other equipment owned by the workshop. The presence of instruments or equipment purchased by the workshop after the date of the initial authorization is also recorded during the control visit.

2) Maintenance, conservation and transmission of inspection documents.

The accredited workshop has to maintain in a proper way the inspection documents. The documents include: the certificate of inspection, the test report and the register of stickers. For each archive, the timing and the mode of document transmission to the authorities is checked.

Both a digital archive and a paper archive are requested. The number of inspection made by the workshop is recorded.

3) Inspection procedure (in progress).

The technician is supervised during an inspection of a sprayer. This control is addressed to verify that the inspection protocol is correctly applied. At the end of the inspection, the release of the inspection documents to the sprayer's owner is also verified.

4) Inspection procedure (follow up).

A sprayer already inspected is verified at the owner place. This sprayer has to be chosen randomly in the archive of the workshop. The inspection shall verify: coherence between the information contained in the inspection documents and the verified elements (i.e. presence of sticker; identification number of inspection; serial number of the machinery; sprayer manufacturer and model; tank dimension; number of nozzles). Then the owner is also identified.

5) Technician legal requirements.

The certificate of attendance of training and refresher courses are verified.

Way of procedure

The inspection is carried out at least by two officers by CRA-ING. A regional officer can possibly participate to the inspection.

They are supported during their work by two preprinted forms to fill during the inspection. The first form concerns the inspection of equipment and instruments (point 1) and the second form the examination of already inspected sprayers (point 4). Each inspection takes about half a day.

At the end of inspection a report is prepared and sent to regional offices in charge. At that point the regional office forwards the report to the workshop. The report contains a table with the synthesis of observations made. Three options are possible: no observation, minor fault or severe fault. The severe faults can include not remediable faults and/or repeated mistakes reported after several checks.

Conclusions

After the first controls of the workshops, no severe faults have been reported. The most part of observations were recorded in the area of maintenance and transmission of the official documents, including delays in transmission time, no proper storage of digital copies of documents. In few cases, mistakes were recorded on the assigned numeration (identification control number) of the inspection.

Some weak points still remain regarding the inspection of a sprayer already inspected at the owner place. In fact, in this case it is very difficult to assign the responsibility of a detected fault, since time is passed between the inspection and, in the meantime, the owner could have changed or replaced (or damaged) parts and component of the equipment. For this reason the second level inspection of a sprayer is limited to some simple points, with the main scope to demonstrate that the inspected sprayer was exactly the same.

Also in the case of function tests of pressure gauges some doubts still remain. In fact the inspection is not allowed to release a calibration certificate and this control could be a controversial point.

In conclusion, the adopted system seems to be suitable to provide a complete inspection to the authorized workshops. However, a higher level of common procedure is still requested in order to achieve a homogenous level of control in all Italian regions.

Session 5: Harmonize the training of the inspectors to achieve the same professional level of the inspections (TWG 5)

Survey about training of sprayer inspectiors and examination procedures for licencing of inspectors in Europe

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The training and examination of sprayer inspectors is an important factor to harmonise inspection procedures between countries and for mutual recognition of inspectors and inspections. The subject has been presented and discussed during SPISE III in Brno 2010 and at SPISE IV in Lana 2012.

During 2013, SPISE TWG 5 made a survey in all EU Member States plus Norway, Serbia and Switzerland regarding the present situation for training an examination of inspectors. 25 countries answered. The questionnaire contained questions about course length, topics in course plan divided in oral lectures and practical, examination procedures and validity time for certificated.

17 countries have answered on questions about the course plan. Several countries have not yet a training system finished and most countries will have to make revisions in training as the new standards for inspection of sprayers in use, the EN ISO 16122 – series, will be implemented. Also examination procedures may need to be revised to get mutual recognition.

The survey has shown two mayor lines of procedures of inspection: Inspection as a pure control and inspection with control plus identification of failures and give recommendations how to repair or to do repairs. The different approaches requires different course plans.

The basis for the training is the baseline for the approved inspectors knowledge, which can has been characterised as:

- Participated and approved in recognized training
- Knowledge of the organizational aspects of inspection and testing procedure
- Able to carry out the test safe and without pollution of the environment.
- Have sufficiently knowledge of the functioning of the sprayer and needs for an effective and efficient execution of the test.
- Can interpret the technical data required for the testing independently and in a correct manner.
- Able to operate the necessary testing equipment and to interpret the measured values in the correct manner.
- Able to carry out the controls and measurements independently and in a correct manner.

- Can use independently and in a correct manner the applying National approval - and rejecting criteria for the sprayers.
- Can fill in independently the testing forms in the obligatory manner
- Can formulate a correct, clear, objective and well founded repair recommendation on the basis of the results of the test to the owner of the sprayer

During examination procedures a combination of oral and practical examination is mainly used among the countries. The examination is often done by external bodies or at least supervised by official authorities.

A main course-structure seems to be suitable; four days with three days training and last day exams. Course-plan may have different emphasis depending on the type of equipment to be inspected, depending on what is dominating in the region.

However, the background training and education of staff that will execute the inspections varies a lot between and within countries. Often mechanics working on shops for agricultural machinery are engaged for the inspections. The background education for those can be broad and deep, specialised in agricultural machinery or more general. Also advisors, with no special mechanical training, perform inspection of sprayers. In many cases inspectors have also many other tasks in the company or organisation. But there are described also situations where staff work full-time with only inspection of sprayers in use.

At the time of the questionnaire, the new harmonised standards, EN ISO 16122-series, where not yet approved or in force, so all information is based on situation based on training to perform the inspections more or less according to the EN 13790. Already at this stage there is a huge span in the training of inspectors, from 1 day plus examination to one month training. The courses may have different focus on sprayer types depending on local variations. Boom sprayers seems to be a general topics but in some areas only sprayers for tree and bush crops exists in other areas only fixed or semi mobile sprayers used in glass houses or nurseries are relevant.

Refresher courses length, content and interval vary. It can be assumed that new refresher-courses needs to be developed to include new sprayer types in the testing schemes. Also the establishment of report systems necessary in a mandatory system needs new training.

Therefore it seems not possible to propose and get acceptance for a common course length or course plan in all countries neither for basic courses nor for refresher courses.

Arrangements of European course to train trainers may however be desirable.

Establishment of a picture gallery regarding training material for inspectors and using it during the testing procedure of pesticide application equipment in horticulture

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Within a system of approved inspection workshops personal must be well trained in order to conduct the inspection according to technical requirements. The task of SPISE should be to harmonize the training of the inspectors in the EU. In this connection the SPISE Working Group 5 is in charge with the preparation of some training material and to offer a picture gallery on the SPISE website.

For this purpose during the last months some course material and information regarding training of inspection personal was collected from several countries.

In the meantime the collected material is published on the SPISE website.

http://spise.jki.bund.de/index.php?menuid=33

It comprises documents in Croatian, Czech, English, German, Italian, Portuguese, Romanian and Spanish language. All this material is prepared for downloading. Due to copyrights each single picture and document is assigned with a copyright mark. In every case customers of that training material may contact the owner of the corresponding document to clarify if an adoption (free or chargeable) could be possible.

The material offers information to all course contents. There are documents which deals with the general knowledge on sprayers and knowledge in spraying including nozzle choice advising. Furthermore material which deals with the general introduction on inspection of sprayers in use is prepared for downloading. Many documents deal with the inspection procedure itself as well as the inspection sites. Also for the test equipment and the calibration of test equipment some information is available. Examples of the training programs and the examinations complement the offered material.

The benefit of such tool shall be illustrated by the example of the testing procedure of PAE in horticulture is totally different compared to field sprayers or mist blowers. The materials downloadable on the JKI website will help the workshop stuff to be well prepared for testing such equipment. Especially points like pump capacity (fig. 1), cross distribution (fig. 2)., etc. needs a special way of testing. With a picture gallery of the specific parts used in practice and slides of good/bad examples should guarantee a harmonized testing of such equipment. In addition a guideline booklet related to that kind of PAE can be used for advising services to explain the gardeners the need of an inspection of the PPE or what is mandatory to be installed on the application equipment.

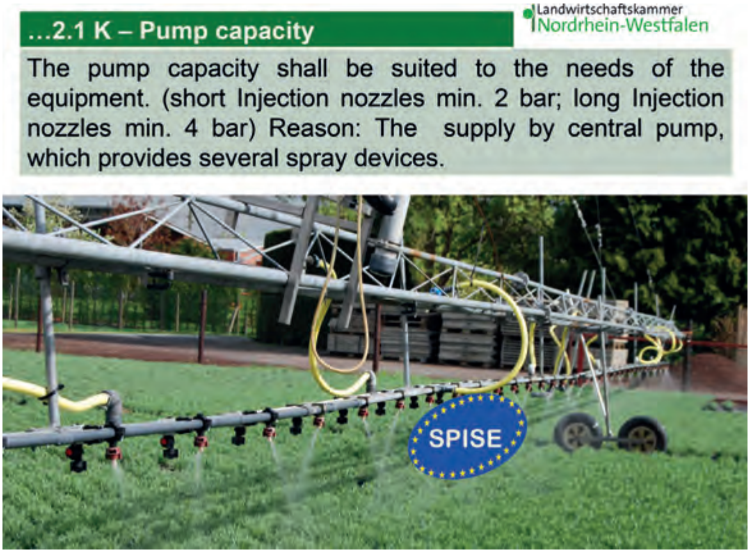

Fig. 1. Special advice for measuring the pump capacity of semi mobile sprayer.

Fig. 2. Measuring the flow rates of single nozzles for evaluation of the cross distribution.

Manual for inspection of sprayers in use and PRITEAF, dedicated software for inspection of sprayers: success tools developed for the inspector's training process in Spain

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Software dedicated to inspection of sprayers in use has been developed with the aim to facilitate the accomplishment of the mandatory requirements from EU Directive for a Sustainable Use of Pesticides, specifically those concerning the inspection of sprayers in use. The software- PRITEAF- has been developed according to the European standards EN 13790 concerning mandatory inspection of sprayers in use and it is ready to be used not only for inspectors among all the EU members but also for training purposes all over the world. The software is ready to be on line –after minor arrangements - with the recently approved new international inspection standards ISO 16122, and its main features are: to facilitate the sprayer's inspection procedure, to manage, storage and transfer all the information to the official bodies in charge of the procedure, and to be used as a support tool to improve the training activities during the process, according the European Directive 2009/128/CE for a Sustainable Use of Pesticides. For this purpose, PRITEAF has been designed for three different types of users: inspection teams, inspection workshops and regional authorities. PRITEAF has been developed using the File Maker Pro package and it is composed of three databases – inspections activities, database on sprayers already inspected, and owners or official responsible for the agricultural activity. The software is completed with specific modules for data acquisition and for generating official reports, files and communications. For its implementation, PRITEAF uses specific hardware (a PC server, a tablet and local Wi-Fi) necessary to ensure proper data collection in the field. After data collection, the software generates an official inspection report and an inspection certificate, as required by law. Using PRITEAF reduces inspection time by 33% compared to traditional sprayer inspection systems. Following its validation, PRITEAF has been made available to regional authorities and inspection workshops across Spain, and is also being used to train all inspection teams in the country. More than 800 inspectors have been officially trained using the developed software, resulting in an interesting tool to improve the daily activities to be executed in all the inspection's workshops in Europe.

Keywords: inspection,sprayers, pesticide application, SPISE, harmonization, training.

Introduction

The inspection of sprayers in use in in all EU Member States (MS) became mandatory after the official publication in October 2009 of the European Directive 2009/128/CE for a Sustainable Use of Pesticides (European Union, 2009). The establishment of a coordinated program of inspections and training, as proposed by the European Commission, has been widely suggested in previous works (Langenakens and Pieters, 1997; Ozkan, 1999; Gil, 2001). The development and promulgation of the Directive has established a uniform framework for the implementation of compulsory inspection of sprayers used throughout Europe (Gil, 2007).

The EU Directive has been incorporated into the national legislation via the National Action Plans. Every single MS has been in charge to develop its own legal framework in order to guarantee the mandatory accomplishment established by EU (Gil et al., 2012; Wehmann, 2009). In the specific case of Spain, the criteria for conducting mandatory inspections are laid out in an Inspection handbook (Gil et al., 2011) edited by the National Authority. This handbook, as occurs in other MS (Balsari et al., 2009; Nilsson and Palsson, 2009) has been established as official guide to help the inspectors to fulfil all the requirements during the inspection procedure.

In general, inspection workshops must use dedicated software to record information generated during an inspection procedure and to issue an inspection certificate. The implementation of any harmonized and international software throughout the Member States will help to develop a standardized inspections' procedure by introducing common inspection protocols according to the sprayer technology (Jones et al., 2000) and by generating information in similar formats. Furthermore, the use of the same inspection software will help to standardize the requested procedure for inspector's training.

The software should be capable of incorporating information generated during inspection in real time, hence maximising the productivity of inspection workshops (Huyghebaert et al., 2007). There are at present several types of inspection software in Europe, some of which have been developed by inspection equipment manufacturers (Herbst and Herbst, 2009; Langenakens, 2009; Mostade and Briffeuil, 2009) and others by authorities responsible for the inspection process. Existing software shows specific differences arising from the inspection protocols and administrative structure in each country. For the latter class of software, computer applications for some of them have been developed and are at varying stages of implementation in Italy (Biocca, 2008), the Netherlands (Kole, 2009), Germany (Haller and Loga, 2007) and Slovakia (Ježík and Lavčák, 2007). In the Netherlands, for instance, the Foundation for Quality Control of Agricultural Machinery (SLK), responsible for organising the inspection of sprayers, has developed a software system which has been obligatory for inspection workshops since 2008 (Kole, 2009).

Researchers have also developed inspection software that helps during the inspections' procedure, and generates the corresponding inspection report and the certificate of inspection (Langenakens, 2009). In this sense, existing inspection software assists the inspector during the controls by providing a "checklist", calculating some control parameters or providing a database of nozzles and component properties (Biocca, 2008). As inspection supervisors need inspection data in digital format, the software must be able to export the required data in a general file format readable by every standard database program (Langenankens, 2009) in order to transfer the information from the inspection workshop to the supervising authorities (Kole, 2009).

In general, existing inspection applications are not very versatile. On one hand, software developed by inspection equipment manufacturers is designed to reliably record information supplied by the specific inspection equipment. On the other hand, software developed by supervising authorities meets European protocols but has specific requirements for each country. It is also interesting to remark the increasing interest for the inspection of sprayers in use in countries outside of Europe. Riquelme et al. (2013) highlighted the importance of the sprayer's inspection program to improve the efficacy during the pesticide application process. Deepening into the topic, Riquelme and Abarca (2013) stated the need to improve the situation of sprayer's equipment in Chile trough a mandatory inspection program, including an accurate training campaign.

The objective of this work was to present two important tools already developed in Spain in order to arrange the mandatory inspection of sprayers in use: a dedicated software to help inspectors during the inspection process, and the official Manual of inspection of sprayers in use adpoted by the Spanish Government as training material during the organized courses.

Software for inspections: a need

The development of any inspection software requires the definition of data acquisition protocols to expedite the inspection procedure. For this purpose, it is necessary to identify the main factors affecting the performance of the inspection. These include the major defects impeding the proper functioning of sprayers, problems related to the use of inspection equipment, hardware required for data collection, and the ability to issue the inspection certificate and the inspection report in real time.

In order to develop the inspection software, a large number of sprayers were selected to be inspected using PRITEAF. 151 sprayers in use (100 air-assisted sprayers and 51 boom sprayers) all of them placed in Aragon region (Spain) and dedicated to the most important productions in the zone as apple, peach, vine, maize and barley, were inspected following the standard procedure and without any dedicated software. The main objective of this activity was to identify factors that affect inspection to determine how the process could be improved. A mobile inspection team of two people carried out the inspections with a minimum of five inspections a day. Data acquisition was manually conducted. The data was recorded on inspection sheets and the information was transferred to a PC for the inspection report. The inspection protocol followed was the one set out in the official European standard (EN 13790-1, 2003; EN 13790-2, 2003). Defects in sprayers and their classification (no defect, minor defect, severe defect) were determined by adopting the criteria in the Inspection handbook edited by the Spanish National Authority (Gil et al., 2011). The basic inspection equipment consisted of the following components: a manometer tester,reference manometers to be placed on the sprayer, a manual flow rate metre for eight nozzles, manometer adaptors, and tools.

Once the whole inspection activity was over, the following requirements were identified in order to establish the software structure:

- Create data collection protocols according to the Inspection handbook or other available official requirements, from the National Authorities.
- Specify different options concerning available hardware ready to directly acquire inspection data without the use of inspection sheets, even in adverse weather conditions of high humidity and low visibility.
- Specify an energy self-sufficient hardware and software system.
- Establish an order of data collection by taking into account the operating sequence of the tractor engine.
- Provide a checklist and database of nozzle and sprayer manufactures to expedite data collection.
- Create a database with information that needs to be transferred to regional and central authorities.
- Generate data files, in the standard format set by the National Authority, to be transferred to the regional and central authorities.
- Calculate the quantitative data related to errors in flow nozzles, the reference manometer pressure and sprayer pressures.
- Issue the inspection report and the inspection certificate.

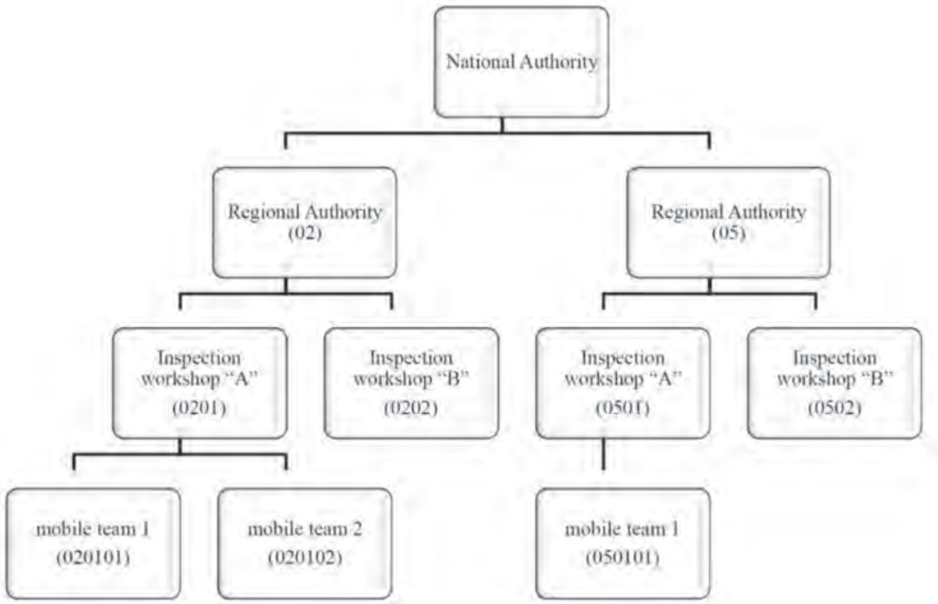

Fig. 1. Example of relationships between the users of the software. National Authority: Ministry of Agriculture; Regional Authority: Autonomous Community (first-level political and administrative division).

Whatever the software will be used, the system should allow fulfilling the specific requirements from at least the three different stakeholder's groups (Fig. 1): a) inspection mobile team; b) inspection workshops; c) regional/national authorities. The software should provide the following functionalities to each type of user:

Inspection team. Performance of the inspection: access to the inspection protocols and databases of nozzles and sprayers; issue the inspection report and certificate; transfer information to the inspection workshop.

Inspection workshop. Manage the inspection information and official documents: allow importing the information from inspections conducted by the mobile teams; transfer the information to regional authorities.

Regional authorities. Manage the inspection information and official documents: allow importing information supplied by the inspection workshops; transferring the information to the National Authority, as specified in the European Directive.

Software development and structure

According to the requirements outlined in the previous section, the developed software (Jimenez, 2014) allows the performance of all operations included in the inspection procedure, i.e., field inspection and administrative tasks associated with the inspection activity. The software has been developed using the File Maker Pro package and was structured into three main databases, a module for data acquisition, and a module for generating reports, files and communications (Fig. 2). The three databases that store structured information are: a) inspections, b) sprayers, and c) sprayer owners.

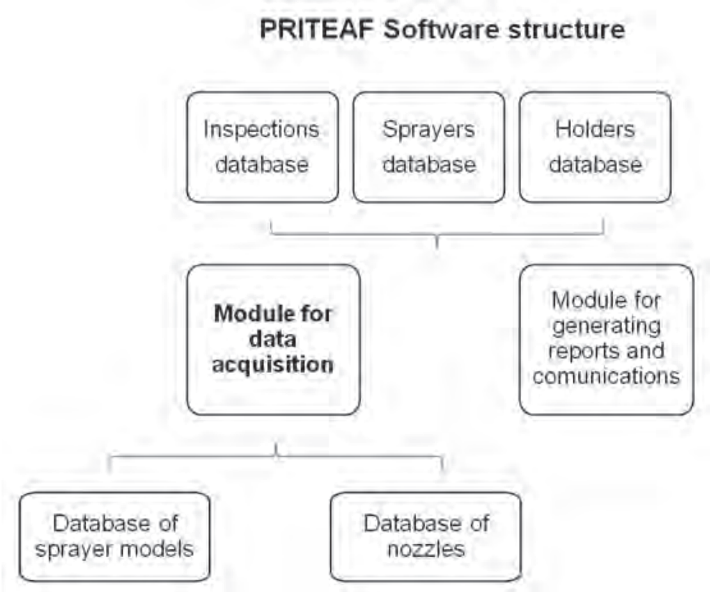

Fig. 2. Architectonic structure of PRITEAF software.

The sprayer owner database stores professional and technical information concerning the sprayer's administrative information. This information is recorded and reused, if it is the case, in subsequent inspections. This database interfaces with the sprayer's database in order to identify other sprayers belonging to the same owner, as well as to retrieve data from previous inspections of these sprayers.

Complementary information included in the databases allows to print, immediately after the inspection process, the official report to be delivered to the user. This official document must be fulfilled following the national or regional rules previously established. Those particular rules, together with the official standards criteria for accept/reject an inspected sprayer have been included in the database.

By analysing the module for data acquisition, the software shows, for each type of sprayer, a submenu with different screens grouped in an order established as a result of our in-field inspection to maximise efficiency in data collection (Fig. 3). The inspector may select different screens on the software without a pre-established order.

Fig. 3. Hardware required by PRITEAF software.

The software consists of several fields to collect inspection data according to the type of information, which is as follows:

Checklist. This is determined directly by the inspector through visual inspection of the machine. There are two types of relevant information: a) presence of the implement (yes, no), b) defect classification (no default, major, minor, not applicable) according the Inspection's Handbook (Gil et al., 2011).

Quantitative measurements. Values obtained during the inspection (pressure, nozzle flow, etc.) are introduced in tables. The system performs calculations to obtain the following indicators: error in the manometer of reference, errors in the pressure of the sprayer sectors, errors in the actual flow rate of the nozzles compared with the nominal flow rate.

Fields for alphanumeric data, such as information relative to the machine and the sprayer holder.

Image container. This is used for storing pictures and anagrams that can be captured directly by the tablet used as hardware for data acquisition, or imported as an external file.

Transfer in three stages of inspection information generated by the software: from the inspection mobile unit to the inspection workshop; from the inspection workshop to the regional authority; and then from the regional authority to the national authority. In general, the software allows to be used independently of the official organization method established at the different countries or communities, due to its adaptability.

Manual of inspection of sprayers in use

Another interesting action to remark as official action implemented in Spain in order to increase the knowledge and education level of the users has been the publication of the Manual of inspection of sprayers in use (Gil et al., 2012).

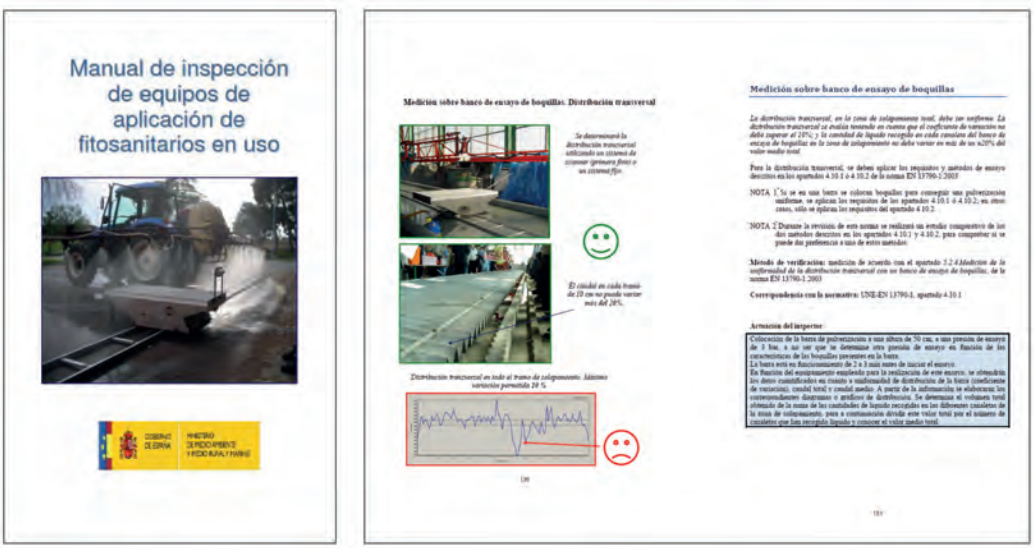

Fig. 4. Manual for inspection of sprayers in use. Main page (left) and structure (right). Available at www.uma.deab.upc.edu and www.magrama.es.

This tool is mainly focused and dedicated to facilitate the comprehension of the whole procedure for the future inspectors and inspection's workshop responsible. The manual (Fig. 4) has been developed by Polytechnic University of Catalonia, University of Lleida and Agricultural Machinery Center of Generalitat de Catalunya, and includes detailed explanation (with graphical and pictures support) of every single action to be developed during the inspection procedure. The main objective of this manual is to facilitate all stakeholders involved in the inspection process the detailed knowledge and habilities to manage the international standards officially in use for the purpose (EN 13790-series). The structure of the manual has been established as a guideline during the practical process of the inspecions. During the whole document, the information and contents have been structured as indicated in Fig. 4. The left part of the book includes specific pictures/graphics concerning the ubject explained in the right part. Pictures with "smiley" emoticons graphically indicate good or bad thinks or aspects to be considered. The righ part of the book contains, for every specific aspect during the inspection process, the official wording according the EU standards, the established procedure (measurement, checking, control...), some practical recommendations for the inspector and the evaluation process depending on the inspection results. The Manual contains all aspects concerning the inspection of sprayers in use, according EN 13790 for a serie of sprayer's tipologies: field crop sprayers, orchard and bush trees sprayers, pneumatic sprayers, dust emissors and hand held trolley sprayers (guns).

After it publication, the Manual has been distributed and widely used in Spain during the mandatory and official training courses on inspection on sprayers in use. In the period of two years (2012-2014), more than 800 inspectors have been trained using the two presented tools, the software and the inspection manual. Results in terms of training quality and comprehension of the whole process have been really interesting and very well appreciated for the attendants. The combination of those two key tools (Fig. 5) allows increasing the quality level of the training activities, makes easier the comprehension of the standards and allow to the users to understand and decide, on every particular case, using the manual as official guideline.

Fig. 5. Official software in combination with inspection handbook allows following the official requirements established by EU 2009/128/CE improving the success of two important aspects: mandatory inspection of sprayers in use and universal training for all the stakeholders.

Conclusions and remarks

After several years of experience using the two devices, the software and the Manual, some conclusions can be addressed:

The structure of PRITEAF is in accordance with the international standards already in use concerning mandatory inspection of sprayers in use (EN 13790) and it is easily adaptable to the new ISO standards recently approved (ISO 16122 series).

The developed software improves the data management system, not only at the workshop facilities, but also during the mandatory data management and data base development by the official responsible of the inspection in Europe.

The use of PRITEAF reduces considerably the risk of mistake during data transcription process or during the evaluation of the obtained data in comparison with the officially established thresholds.

Manual of inspections have been considered as the oficial guideline for inspection of sprayers in use in Spain and it has been officially supported by the Spanish Ministry of Agriculture.

The structure, contents and explanations allow to attendants a better comprehension and application of the standards, which sometimes are not as clear as intended to be.

As both elements have been developed following a similar structure, this aspect has been very well appreciated for the attendants to the mandatory courses, helping them in the knowledgement process.

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Session 6: Minimum workshop facilities necessary to make an appropriate sprayer adjustment of orchard sprayer at the workshop during the inspection (TWG 6)

SPISE guidelines on how to make sprayer adjustment at the workshop as an addition to the functional inspection of field crop sprayers

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In the ambit of SPISE working Group several Technical Working Groups (TWG) have been recently created with the aim to prepare guidelines about the items taken into account by the EU Directive 128/2009/EC but still not considered in the actual ISO/CEN standards.

SPISE TWG 6 in particular has defined guidelines on what are the minimum workshop facilities necessary and how to make an appropriate sprayer adjustment of field crop sprayers at the workshop during the inspection/calibration activities.

Sprayer adjustment is focused to the adaptation of the sprayer output (both liquid and air) to the specific crop and eventually environmental situations present on the farm. To guide and verify the correct sprayer adjustment at the workshop, it is necessary to use ad hoc test benches that the workshops should have in their set of instruments.

It is an operation that shall be made at the end of the functional inspection but before the eventual calibration of the sprayer. It has to be carried out for each crop type and situation present on the farm or at least for the most representative ones, because only a correct adjusted sprayer guarantees that the spray mixture is addressed to the target, the use of PPP is optimized and the risks for the environment (e.g. spray drift) and for the consumers are minimized.

For these reasons an advice with the following content will be published:

Foreword

The SPISE Working Group was established in 2004 during the first SPISE workshop. There the participants welcomed the thought of Dr. Ganzelmeier (JKI) that a working group should work on further steps for the harmonization and mutual acceptance of equipment inspections. In the following years, thanks to SPISE engagement, a constant exchange of information has been made possible within the working group and consultations went on between the EC and MS on improving the sustainability of plant protection.

The 5 members of the SPISE working group came from Belgium, France, Germany, Italy and the Netherlands. They represented the member states with most experience in the fields of inspection of sprayers at that time.

In the ambit of SPISE working Group several Technical Working Groups (TWG) have been recently created with the aim to prepare guidelines about the items taken into account by the EU Directive 128/2009/EC but still not considered in the actual ISO/CEN standards.

SPISE TWG 6 (°), in particular, has defined guidelines on how and what are the minimal workshop facilities necessary to make an appropriate sprayer adjustment of field crop sprayer at the workshop during the inspection/calibration activity.

(°)SPISE TWG 6 members

Chairmen:

Balsari Paolo, DISAFA, Italy

Herbst Andreas, JKI, Germany

Langenakens Jan, A.A.M.S. NV, Belgium

Introduction

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

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

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

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

This document provides some guidelines on how to operate field crop sprayer **adjustment** at the workshop and about the type of instruments needed, with their minimum technical requirements.

1. Sprayer adjustment

It is an operation that shall be made at the end of the functional inspection, but before the eventual calibration of the sprayer. It has to be carried out for each crop type and situation present in the farm or at least for the most representative ones, because only a correct adjusted sprayer guarantees that the spray mixture is addressed to the target, the use of PPP is optimized and the risks for the environment (e.g. spray drift) and for the consumers are minimized (Andersen & Jørgensen, 2009).

The operative parameters of the sprayer that is recommended to take into account for the sprayer adjustment made at the workshop are the following:

Optimal boom height selected according to the nozzle type used, the target crop height and the environmental conditions;

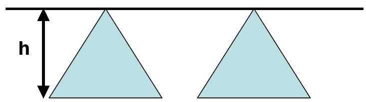
Air velocity and direction (only if the spray boom is equipped with an air sleeve) selected according to the target crop type and the environmental conditions.

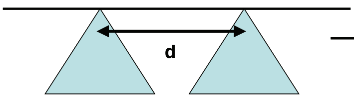
2. Optimal boom height

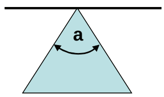
Indications on optimal boom height

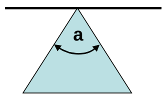
In order to achieve a sufficient evenness of transversal spray distribution, it is necessary to operate with an appropriate spray boom working height. As boom height it is intended the distance between the nozzle tip and the target (crop or soil). For boom height selection it is important to consider the spray angle of the nozzles mounted along the boom and their spacing (Tab. 1). In general terms nozzles featured by wide spray angles are preferable because they allow reducing the boom height and therefore mitigating spray drift (Fig. 1 and Fig. 2). Especially when wide boom sprayers are employed, it is recommended to keep a boom not lower than 0.50 m in order to prevent the ends of the boom from hitting the ground.

Tab. 1. Boom heights enabling to achieve the correct spray jets overlapping in function of the nozzle type and of the nozzle spray angle









	boom height (m)		
Nozzles spacing (m)	Hollow cone nozzles	Flat fan nozzles	
	α = 80° /90°	α = 80° /90°	α = 110° /120°
0,25	-	-	*0,30*
0,33	*0,50*	*0,50*	*0,40*
0,50	*0,75*	*0,75*	*0,50*

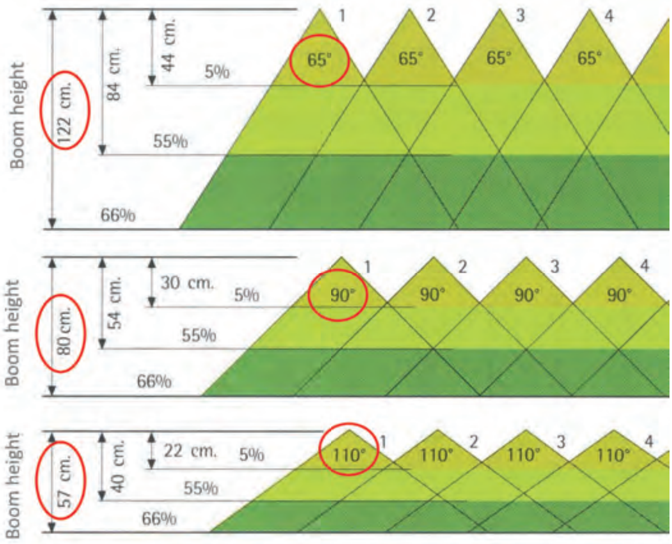


Fig. 1. Nozzle with wide angle allowed to maintain the boom closer to the target using the same spray overlapping and minimizing spray drift losses.

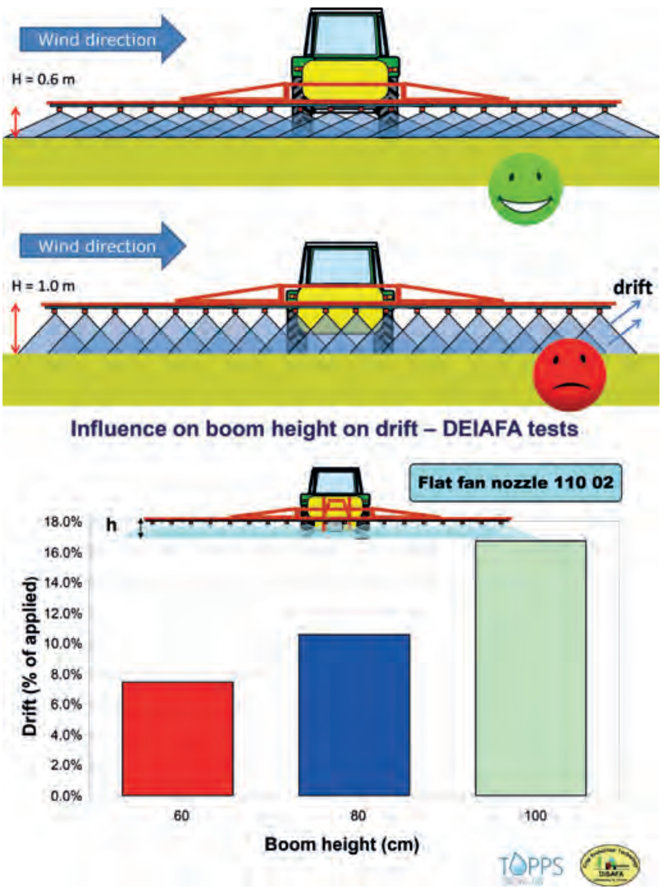


Fig. 2. Influence of boom height on spray drift (Marucco & Tamagnone, 2002).

When specific nozzles for band spray application are used the boom height adjustment is dependent on the spray angle, nozzle twist and nozzle spacing. Boom height shall be set to achieve a correct spray distribution on the applied band and to prevent spray drift.

Note: Consider the real spray angle, at lower pressures angles become smaller than the indicated spray angle. Some manufacturers are not precise in mentioning the spray angle for commercial reasons.

Optimal boom height evaluation

The optimal boom height is the one which allows obtaining the most even transverse spray distribution diagram according to the intended spray application (open field or band treatment).

The assessment of the optimal boom height shall be carried out in the area of the overlapping spray jets, excluding the outer parts of the boom while the nozzles are operated at the pressure indicated by the professional user and using a horizontal patternator, according to chapter 5.6.1 of EN ISO 16122-2.

Minimum technical features of this patternator are:

- grooves 100 ± 2,5 mm wide and at least 80 mm deep, measured as a distance between the top and the bottom of the groove
- Length of the groove: at least 1,5 m.

The groove width of a patternator working in steps with electronic data sampling (e.g. scanners) shall be 100 mm ± 1 mm.

The error of measurement shall not be more than 10 ml or ± 2 % of the measured value whichever is greater.

When passing the measuring track, positioning in single steps shall be completed with an accuracy of ± 20 mm. The measuring error of the volume of the single grooves at a flow volume of 300 ml/min shall be less than ± 4 %. The adjustment and calibration of the patternator shall be in accordance with the patternator manufacturer's instruction handbook.

Influences by external conditions on the reproducibility on the results shall be minimized.

Optimal boom height determination

Manual Test bench

After checking that the field crop sprayer is positioned on a horizontal surface and is set according to the parameters (operating pressure and boom height) normally used in the farm, activate the nozzles and position the test bench (Fig. 3) under the boom section to examine.

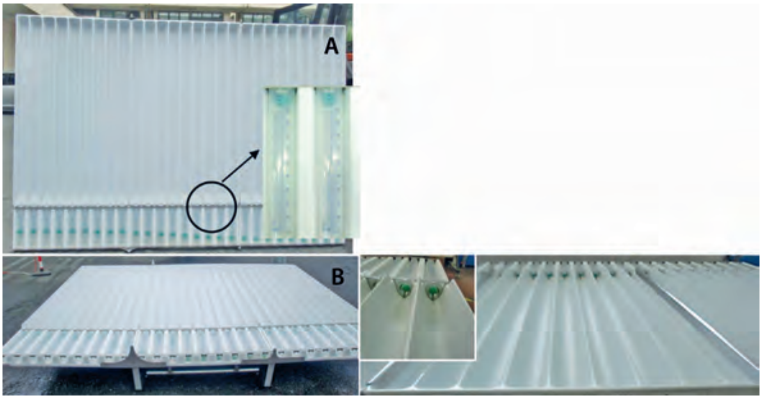


Fig. 3. Examples of manual horizontal patternator.

If the sprayer is equipped with an air sleeve, the test is carried out with the fan disabled or if it cannot be disabled, at the lowest possible pressure

The test shall be repeated for all the nozzle series present on the boom sprayer and used in the farm.

Duration of the test depends on the technical features of the test bench and on the nozzles flow rate (Tab. 2).

At the end of the trial the uniformity of transverse spray distribution under the boom is assessed visually on the test bench, looking at the profile of the water in the filled grooves. The presence of floats inside the collecting tubes of the test bench allows making a simpler and quicker evaluation (Fig. 6).

For the interpretation of the result it is important to consider the nozzle type used: for instance, using hollow cone nozzles it will never be possible to achieve the uniformity level reached using flat fan nozzles, while the specific nozzles for band spraying shall show spray distribution peaks in correspondence of each nozzle position.

	Spaziatura ugelli sulla barra (m)		
	0,33	0,50	1,00
Portata ugelli (l/min)	Tempo (s)		
0,2	257	390	780
0,3	172	260	520
0,4	129	195	390
0,5	103	156	312
0,6	86	130	260
0,7	74	111	223
0,8	64	98	195
0,9	57	87	173
1,0	51	78	156
1,2	43	65	130
1,4	37	56	111
1,6	32	49	98
1,8	29	43	87
2,0	26	39	78
2,2	23	35	71
2,4	21	33	65
2,6	20	30	60
2,8	18	28	56
3,0	17	26	52
3,5	15	22	45
4,0	13	20	39

	Spaziatura ugelli (m)		
	0,33	0,5	1
Portata ugelli (l/min)	Tempo (s)		
0,2	297	450	900
0,3	198	300	600
0,4	149	225	450
0,5	119	180	360
0,6	99	150	300
0,7	85	129	257
0,8	74	113	225
0,9	66	100	200
1,0	59	90	180
1,2	50	75	150
1,4	42	64	129
1,6	37	56	113
1,8	33	50	100
2,0	30	45	90
2,2	27	41	82
2,4	25	38	75
2,6	23	35	69
2,8	21	32	64
3,0	20	30	60
3,5	17	26	51
4,0	15	23	45

Tab. 2. Examples of tables reporting the time of spraying, depending on nozzles flow rate, for tests made using manual test benches (grooves width 100 mm, groove depth 96 mm) having different collecting surfaces: A): height of collecting surface 0.90 m, tube height: 0.27 m - B): height of collecting surface: 1.50 m, tube height: 0.40 m   Diese Tabelle ist eine Abbildung!!!

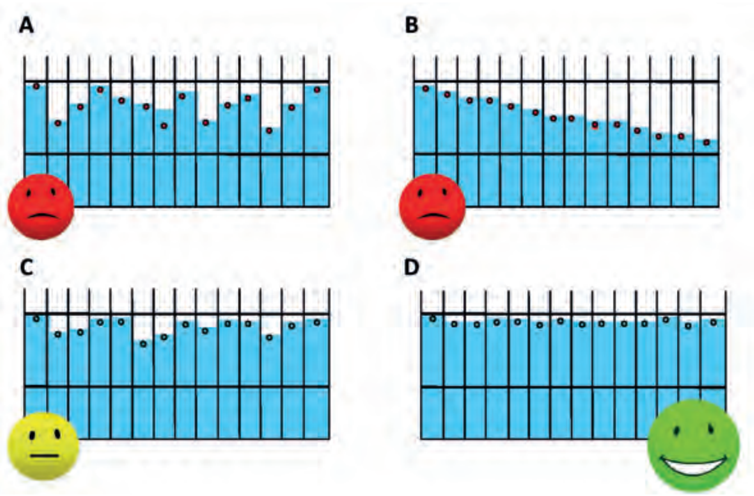


Fig. 4. Evaluation of transverse spray distribution diagrams to individuate the optimal boom height. A and B) necessity to act on nozzles, C) necessity to modify the boom height, D) optimal boom height.

Electronic test bench (e.g. "scanner")

After checking that the field crop sprayer is positioned on a horizontal surface and is set according to the parameters (operating pressure and boom height) normally used in the farm, activate the nozzles and the data acquisition from the test bench (Fig. 5) that shall be already positioned under the boom sprayer to evaluate.

If the sprayer is equipped with an air sleeve, the test is carried out with the fan disabled or if it cannot be disabled, at the lowest possible pressure. The test shall be repeated for all the nozzle series present on the boom sprayer and used in the farm.

Fig. 5. Examples of electronic horizontal test benches (e.g. "scanner" type).

The test bench works autonomously under the boom. Generally the test bench displacement from one position to the next under the boom is related to the filling of the tubes in the collecting grooves.

At the end of the test, the system generally provides on the PC the graph of the liquid profile of the collected liquid with the corresponding coefficient of variation. According to the amount of this obtained value it is possible to make further tests at different boom heights and or pressures

3. Air velocity

When air-assisted boom sprayers are operated, it is necessary to adjust the air stream velocity and the inclination of the nozzles (or of the air sleeve itself, when possible) with respect to the air flux according to the spray application conditions (Balsari et *al*. 2013).

In detail:

4. Disconnect the fan when applying on bare soil (ensure that the air sleeve not interfere with the spray);

5. When spraying low crops reduce the air velocity in order to prevent dust generation and orient the air stream backwards to avoid bouncing of the sprayed droplets;

6. When it is necessary to achieve a better spray droplets penetration into dense canopies, increase the air velocity and orient the air stream conveniently to open the canopy and to support droplets penetration;

7. In presence of side wind or in absence of wind, keep the air stream direction vertical and only orient it forwards if the forward speed exceeds 8 km/h;

8. In presence of back wind orient the air stream backward;

9. In presence of front wind orient the air stream forward (Fig. 6);

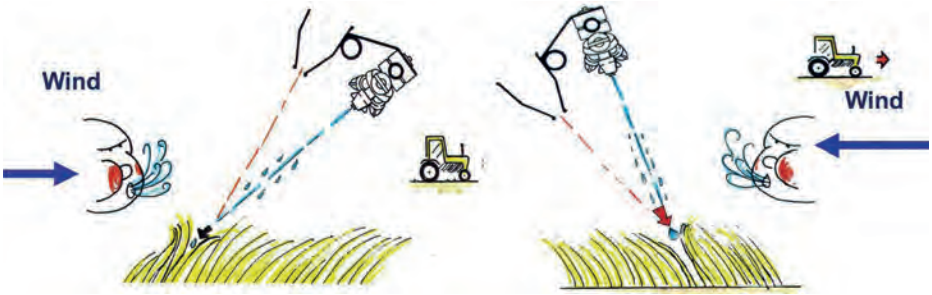


Fig. 6. Air sleeve adjustment to contrast the action of wind and to prevent spray drift.

Always carefully control the meteorological conditions in which the spray application is carried out. If wind speed and direction change it is recommended to modify the orientation of the air stream conveniently.

To assess the air velocity it is necessary to use a specific test bench provided with an anemometer (Fig. 7) having **at least** the following **technical features**:

Numbers of anemometers: 1

Anemometer measuring range: 0÷25 m/s

Error: max. 0.25 m/s

Longitudinal distance between measurement positions: max. 100 mm

Transversal distance between measurement positions: max. 500 mm

Number of measurements per position: 1

Fig. 7. Example of test bench equipped with sonic anemometer.

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Perfformances evaluation of different vertical patternators

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Summary

Assessment of vertical spray profile is one of the main steps to adjust sprayers for bush and tree crops, as it allows to verify that the spray plume matches the target canopy profile.

The equipment used for assessing the vertical spray profile is typically a vertical test bench or patternator.

Even if the sprayer adjustment is recommended in EU Directive 128/2009/EC, the use of vertical test benches is only optional in the procedures for the inspection of air-assisted sprayers in use currently adopted in the EU Member States, that mainly refer to EN 13790-2 and to new ENISO FDIS 16122-3.

At present, in the International Standards, there is not any indication of the minimum requirements that the vertical test benches have to fulfill, neither in terms of constructive characteristics or of functional parameters.

For this reason, the types of vertical test benches used in the test stations, even if are based on the same principle of functioning (presence of a vertical surface to collect the whole liquid sprayed and of graduated tubes for measuring it), present some differences in terms of structure, mainly related to collectors types and their disposal along the test bench.

Two main categories of vertical test benches can be identified: 1) equipped with a continuous collecting wall; 2) equipped with a discrete number of separated collectors. In each category it is then possible to have different models, depending on the size, materials, number and position of the collectors.

With the main purpose to define methodology and criteria for the vertical patternator evaluation, specific performance tests were carried out in laboratory using four different types of vertical test benches and a horizontal test bench complying with ISO 5682-1 requirements. Spray recovery capacity and reproducibility of results, both in terms of recovery and of spray profile were assessed using different droplet sizes, air speeds and air directions.

Results of these first experimental trials pointed out that the criteria applied to assess the performance of the vertical test benches seemed able to discriminate the differences between the models tested. Amount of spray recovery was mostly affected by droplets size rather than by air velocity. Spray profile detected on the different vertical patternator types examined resulted generally similar. These first experimental results could constitute a basis for the development of a SPISE advice about test methodology and requirements for vertical test benches.

Introduction

Proper adjustment of vertical spray profile is a key aspect to optimize pesticide application with air-assisted sprayers for orchards and vineyards. The spray profile, in fact, shall be adequate to the target canopy profile in order to address the spray plume only in correspondence of the target and to minimize off-target losses. A useful tool enabling to assess the vertical spray profile produced by an air-assisted sprayer is a vertical test bench that enables to collect the liquid sprayed at the different heights and therefore allows to verify the overall vertical spray profile (Pergher *et al.*, 2002).

As there are different types of such vertical test benches available on the market but, at present, there is not any specific Standard that indicates the minimum technical features and requirements that these devices should match, experimental tests at Crop Protection Technology DISAFA laboratory were carried out in order to evaluate the performances of some different models of vertical test benches. The aim was to pave the way to a SPISE advice about test methodology and requirements that in future could be applied to such devices.

Materials and methods

Tests were carried out comparing 5 different types of test benches (4 vertical and 1 horizontal), featured by different shapes and sizes of the spray collecting surfaces.

Three vertical test benches were constituted by discrete plates disposed along the vertical frame of the bench having the following technical features:

Test bench equipped with stainless steel plates 300 x 100 mm size (collecting surface of each single plate equals to 300 cm^2) and spacing between consecutive plates along the vertical axis (vertical resolution) of 100 mm. Plates are disposed in three vertical arrays. First plate is positioned at 455 mm height from the ground. Maximum height of the test bench is 4500 mm, total width is 1000 mm (Fig. 1A).

Test bench equipped with stainless steel plates 200 x 200 mm size (collecting surface of each single plate equals to 368 cm^2) and vertical resolution of 200 mm. Plates are disposed in two vertical arrays. First plate is positioned at 465 mm height from the ground. Maximum height of the test bench is 4500 mm, total width is 640 mm (Fig. 1B).

Test bench equipped with plastic plates 200 x 220 mm size (collecting surface of each single plate equals to 437 cm^2) and vertical resolution of 200 mm. Plates are disposed in two vertical arrays. First plate is positioned at 500 mm height from the ground. Maximum total height of the test bench is 4500 mm, total width is 640 mm (Fig. 1C).

In all the three models the liquid collected by the plates is conveyed to graduated tubes by means of small pipes.

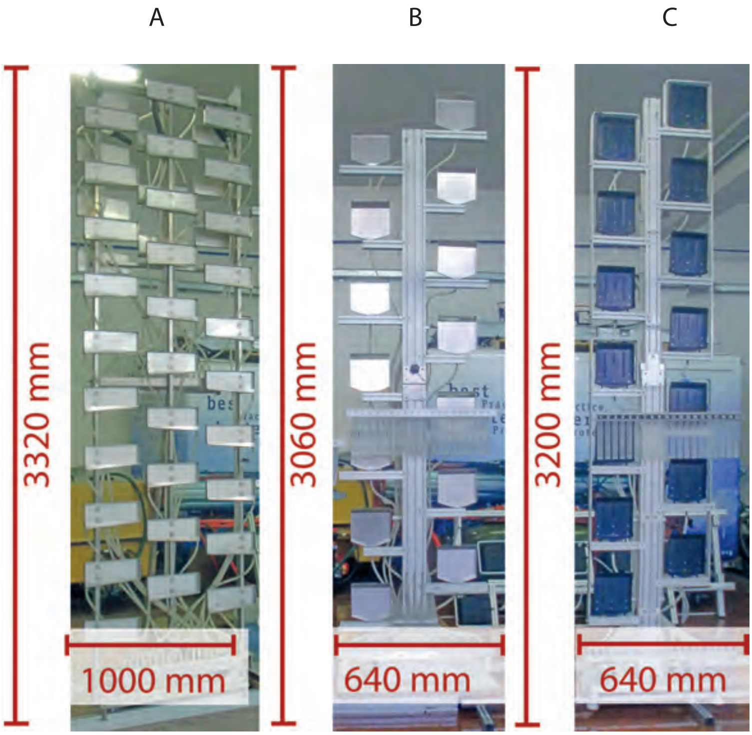

Fig. 1. The three types of vertical test benches fitted with discrete spray collectors used in the tests with relative heights.

The fourth model of vertical test bench examined was a patternator equipped with 96 horizontal lamellae made of plastic inserted in a stainless steel frame. Vertical resolution of this test bench is 100 mm, corresponding to the collecting surface of three lamellae (the liquid captured by three consecutive lamellae is conveyed to a graduated tube). First lamella is positioned at 310 mm height from the ground. Total height of the test bench is 3500 mm, total width is 1800 mm (Fig. 2).

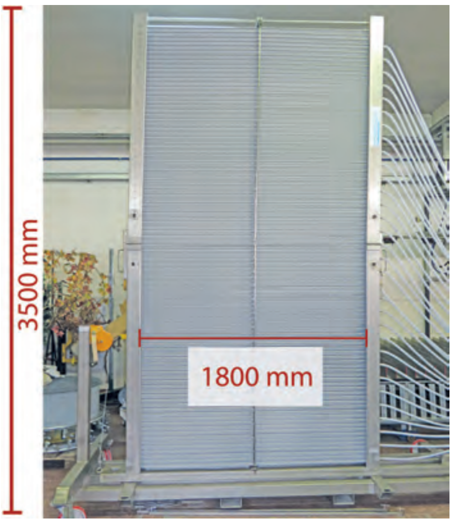

Fig. 2. Lamellae vertical patternator examined in the trials.

A fifth test bench used for comparison was constituted by a stainless steel horizontal test bench complying with ISO 5682-1 standard (Fig. 3). The test bench, 6 m wide, is equipped with 60 grooves, each 100 mm wide, 200 mm deep and 2000 mm long. The liquid recovered in each groove is collected in a graduated tube 500 ml capacity.

The choice to use also this standardized horizontal test bench was made in order to get some reference data to compare with the results obtained using the vertical test benches.

Fig. 3. Horizontal test bench complying with ISO 5682-1 standard used in the tests.

All tests were carried out at Crop protection Technology DiSAFA laboratory using a spraying unit electrically driven consisting in a tangential fan 1440 mm high and with a fan diameter of 150 mm, combined with five hydraulic nozzles mounted on a vertical spray boom at 300 mm spacing. In all tests, the spraying unit was positioned at a distance of 800 mm from the test benches and just one nozzle – the one positioned in the middle of the spraying unit - was activated.

Spraying parameters considered during the tests were droplets size, air velocity and air direction.

Three different conventional hollow cone nozzles and three different air induction hollow cone nozzles, always operated at 0.10 MPa pressure, were used in the tests in order to assess the effect of droplet size (VMD) ranging from 70 to 460 µm (Tab. 1).

Tab. 1. Nozzle types with related droplet size employed in the tests.

Nozzle model	Type	Flow rate (l/min) at 0.10 MPa	VMD (µm)
Teejet TXB 8001VK	Conventional hollow cone	0.68	70
Teejet TXB 8002VK	Conventional hollow cone	1.44	80
Teejet TXB 8004VK	Conventional hollow cone	2.75	105
Teejet AITXB 8001VK	Air induction hollow cone	0.70	245
Teejet AITXB 8002VK	Air induction hollow cone	1.45	380
Teejet AITXB 8004VK	Air induction hollow cone	2.75	460

Three different air velocities, measured in correspondence of the test benches, therefore at 80 cm distance from the spraying unit, were applied in the tests: 5.0 m/s; 8.2 m/s; 12.5 m/s. For each air velocity value, all the nozzles were tested, therefore 18 spraying unit configurations were tested keeping the spraying unit vertical (spray jet and air flow perpendicular vs. the test bench, Fig. 4A) and 18 configurations were tested positioning the spraying unit inclined 30° with respect to the vertical axis (spray jet and air flow inclined vs. the test bench, Fig. 4B).

A B

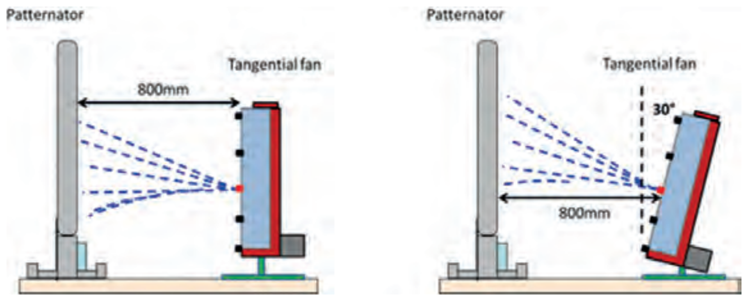

Fig. 4. Positions of the spraying unit with respect to the test bench examined in the tests.

For each test bench and for each spraying unit configuration three test replicates were carried out.

Trials made using the vertical test benches equipped with plates were made keeping them static and moving the spraying unit in front of them at 60 mm/s forward speed along a motorized rail track. Tests made with the lamellae patternator and with the horizontal test bench were carried out keeping both the spraying unit and the test bench in static position. When the standardized horizontal test bench was employed, the spraying unit was suspended over it at a distance of 800 mm (Fig. 5) so that the spray jet and the air flow were addressed perpendicular to the spray collecting surface. In this latter case it was not possible to carry out the tests with the spraying unit inclined with respect to the test bench.

Fig. 5. Position of the spraying unit with respect to the horizontal test bench.

Three criteria for assessing the performance of the test benches according to the different spraying unit configurations examined were applied:

Spray recovery capacity;

Reproducibility of the recovery capacity results;

Spray profile reproducibility.

Spray recovery capacity was determined measured the amount of liquid collected by each test bench with respect to the total amount of liquid sprayed during the test.

Concerning the three test benches equipped with plates (discrete collecting elements), taking in account that the spraying unit moved in front of them during the trials, the recovery capacity (RC) was calculated according to the following formula:

$$RC = \left(\sum_{i=1}^{n} a_i/s\right)/(Q * t)$$

where:

a_i is the amount of liquid collected by each single plate (ml)

s is the number of passes made by the spraying unit in front of the test bench

Q is the spraying unit flow rate, expressed in ml/s

t is the time (s) spent by the spraying unit in front of the test bench during one pass (function of forward speed and collector width)

For the lamellae vertical patternator and for the horizontal test bench, considering that the spraying unit was operated in static position, the spray recovery capacity (RC) was calculated through the formula:

$$RC = \sum_{i=1}^{n} a_i/Q$$

where:

a_i is the amount of liquid (ml/min) collected in each graduated tube of the test bench;

Q is the spraying unit flow rate, expressed in ml/min

In both the formulas, the amount of liquid collected was considered as the mean value of the three test replicates.

To evaluate the reproducibility of the spray recovery capacity, for each sprayer configuration examined and for each test bench, the coefficient of variation calculated between the values obtained in three test replicates was considered.

Finally, to assess the reproducibility of the spray profile on the same test bench, a specific Spray Profile Index (SPI) was calculated as the total sum of the differences between maximum and minimum values of the spray liquid amount collected at each sampling height along the test bench, obtained in the three test replicates. All the amounts of spray liquid collected at the different sampling heights were expressed as percentage of the total recovery on the test bench.

The lower is SPI value, the more similar the spray profiles are.

$$SPI = \sum^{n} (max - min)$$

Results

Spray recovery capacity

Results obtained using the different test benches pointed out that, keeping the air velocity constant, the spray recovery capacity increases according to the droplets size (VMD). When very fine droplets were applied (VMD around 100 µm), generally only 50% of the sprayed liquid was collected by the test benches (Fig. 6); the recovery capacity increased up to 90% when the medium-coarse droplets, featured by a VMD ranging from 245 to 460 µm, were sprayed. Highest values of spray recovery were registered using the vertical test bench equipped with the plastic plates. This trend was confirmed also when the spray unit was inclined 30° with respect to the vertical test benches (Fig. 7).

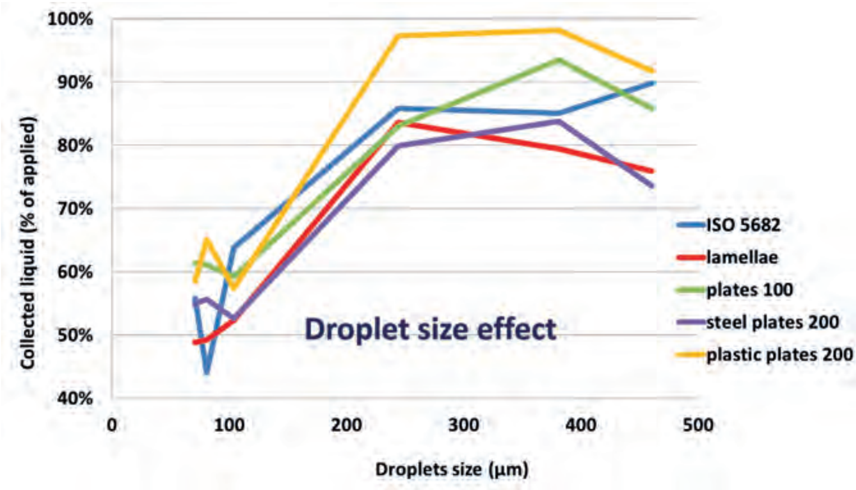

Fig. 6. Spray recovery registered for the different test benches examined according to the droplets size (VMD, µm). Data referred to tests carried out employing an air velocity of 8.2 m/s and addressing the spray jet and air flow perpendicular to the test bench.

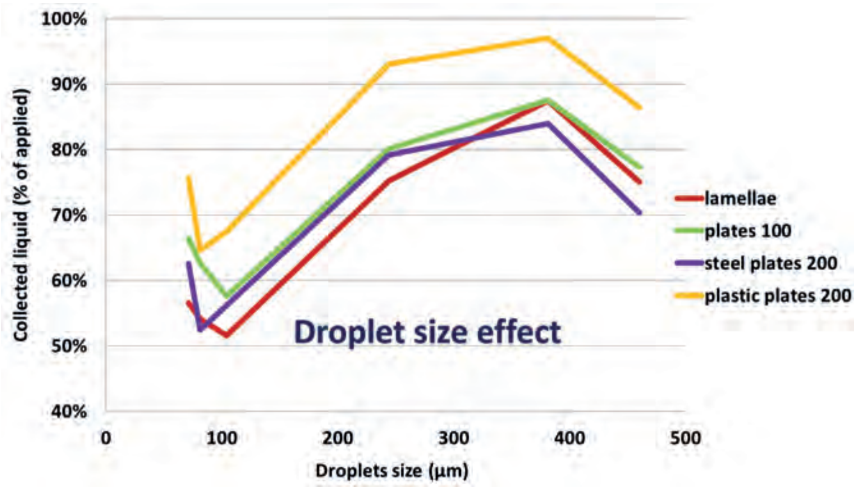

Fig. 7. Spray recovery registered for the different test benches examined according to the droplets size (VMD, µm). Data referred to tests carried out employing an air velocity of 8.2 m/s and operating the spray unit inclined 30° with respect to the vertical test benches.

Effect of the air velocity on spray recovery was very limited when the fine droplets (VMD = 105 µm) were sprayed, except than for the horizontal test bench ISO 5682, where the increment of the air velocity probably enhanced rebounds of droplets from the bench and therefore reduced the spray recovery capacity (Fig. 8).

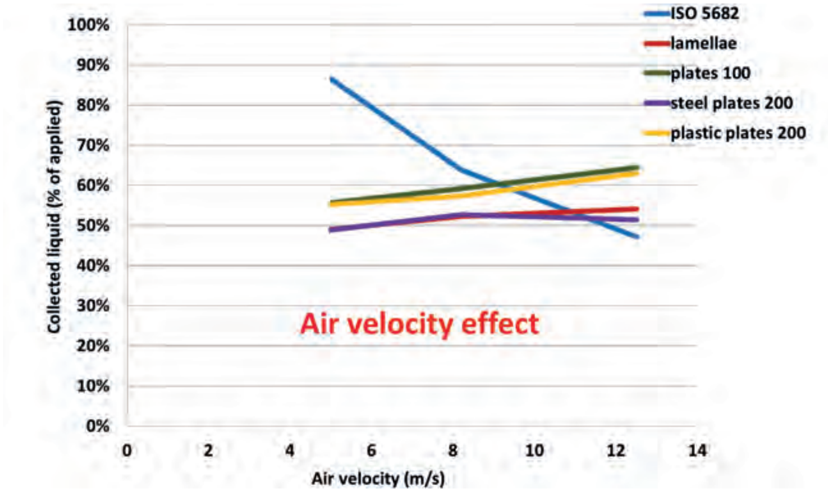

Fig. 8. Spray recovery registered for the different test benches examined according to the air velocity employed, when fine droplets were applied (VMD = 105 µm). Data referred to tests carried out employing TXB 8004 VK nozzle and addressing the spray jet and air flow perpendicular to the test bench.

On the other hand, when the coarse droplets (VMD = 460 µm) were applied, at high air velocity (12.5 m/s) a decrease of spray recovery capacity of the test benches was generally observed (Fig. 9). This trend was noticed for most of the test benches (in particular for the horizontal test bench ISO 5682), except than for the lamellae test bench. For this latter patternator, in fact, a higher spray recovery was registered employing the maximum air velocity.

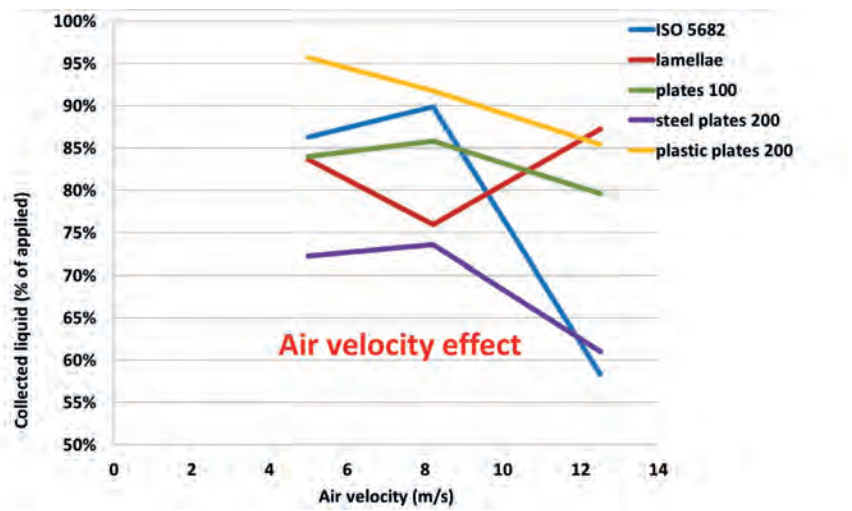

Fig. 9. Spray recovery registered for the different test benches examined according to the air velocity employed, when coarse droplets were applied (VMD = 460 µm). Data referred to tests carried out employing AITXB 8004 VK nozzle and addressing the spray jet and air flow perpendicular to the test bench.

Reproducibility of the recovery capacity results

The analysis of the coefficient of variation calculated on the three replicates of each test (combination of nozzle type and air velocity) pointed out that, when the spray jet was addressed perpendicular to the test bench - independent of the test bench model -, the reproducibility of the spray recovery results was pretty good (CV < 10 %), especially when the medium/coarse droplets were applied (Fig. 10). Higher CV values, around 20% between the three test replicates, were found spraying the very fine droplets on the vertical test benches equipped with plates (Fig. 10).

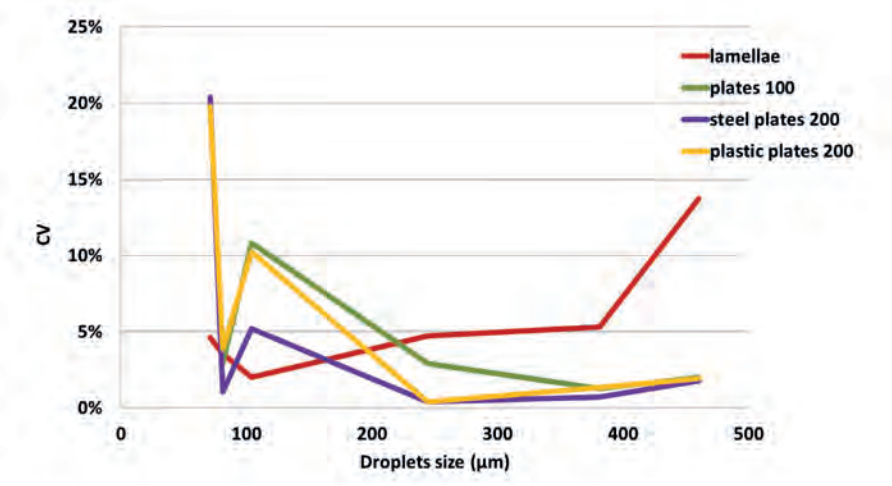

Fig. 10. Reproducibility of the spray recovery results (CV) registered for the different test benches examined according to the droplets size. Data referred to tests carried out employing the air velocity of 8.2 m/s and addressing the spray jet and air flow perpendicular to the test bench.

When the spray unit was rotated 30° with respect to the vertical test benches (see Fig. 4B) the reproducibility of spray recovery results was even better (CV below 5%) when the test benches equipped with plates were used, while it was poorer when the lamellae patternator was employed. In this latter case the CV resulted often over 10%, except when coarse droplets were sprayed (Fig. 11).

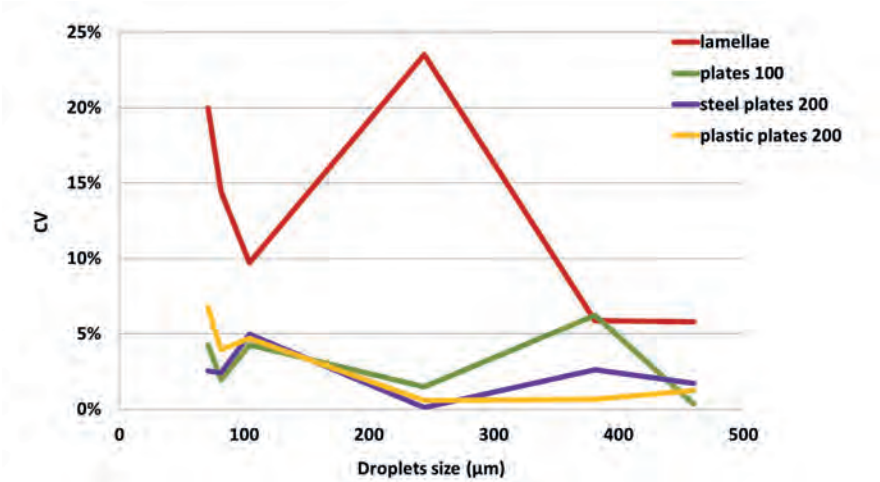

Fig. 11. Reproducibility of the spray recovery results (CV) registered for the different test benches examined according to the droplets size. Data referred to tests carried out employing the air velocity of 8.2 m/s and operating the spray unit inclined 30° with respect to the vertical test benches.

Spray profile reproducibility

Assessment of spray profile reproducibility carried out through the calculation of the Spray Profile Index (SPI) pointed out that, when the spray jet was addressed perpendicular to the test bench and the medium/coarse droplets were sprayed, a high reproducibility of the profiles, with SPI values below 0.1, was found using the vertical test benches equipped with plates (Fig. 12); more differences between the spray profiles obtained during the test replicates were noticed when the very fine droplets were applied, with SPI values up to 0.4. Concerning the lamellae patternator, a different trend of the reproducibility of the spray profile was noticed, as SPI resulted very low even when the fine droplets were used, but it grew over 0.2 when the coarse droplets were sprayed (Fig. 12).

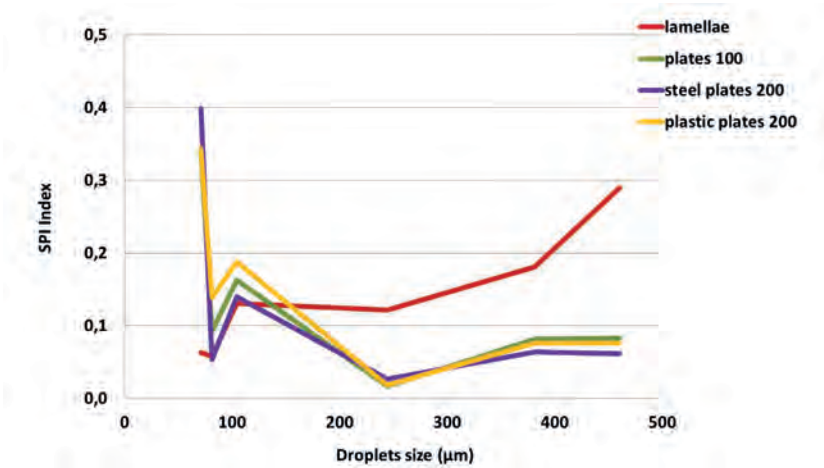

Fig. 12. Trend of Spray Profile Index (SPI) registered for the different test benches examined according to the droplets size. Data referred to tests carried out employing the air velocity of 8.2 m/s and addressing the spray jet and air flow perpendicular to the test bench.

When the spray unit was rotated 30° with respect to the vertical test benches, the reproducibility of the spray profiles generally resulted better, especially employing the vertical test benches equipped with plates, with SPI values always below 0.15 (Fig. 13).

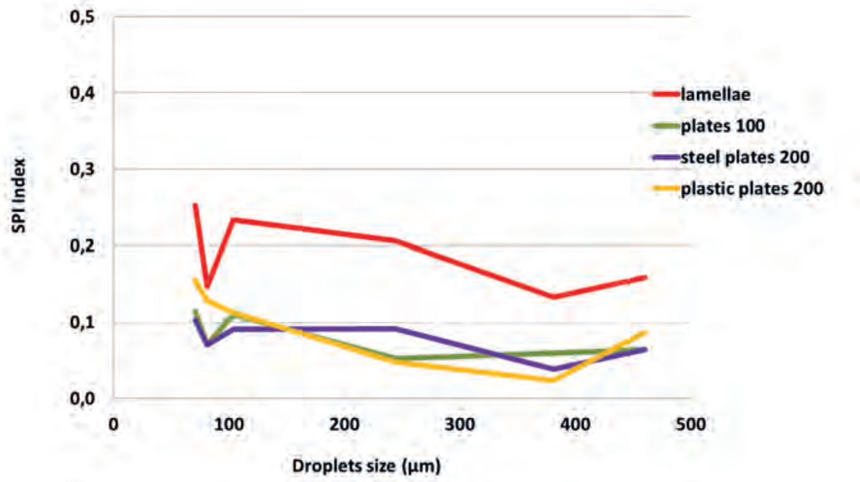

Fig. 13. Trend of Spray Profile Index (SPI) registered for the different test benches examined according to the droplets size. Data referred to tests carried out employing the air velocity of 8.2 m/s and operating the spray unit inclined 30° with respect to the vertical test benches.

Conclusions

The criteria applied for the evaluation of the vertical patternator performance seemed able to discriminate the differences between the five types tested. Spray quality influenced spray recovery, with higher collection efficiency of the test benches observed when medium/coarse droplets were sprayed. The effect on spray recovery of air velocity, in the range considered during the experiments (5.0 ÷ 12.5 m/s), resulted very low. The reproducibility of spray recovery was pretty good with all the test bench models assessed, as the coefficient of variation between three test replicates resulted within 20%. For each combination of nozzle and air velocity examined, the spray profiles detected on the different models of vertical test benches generally resulted similar (Fig. 14).

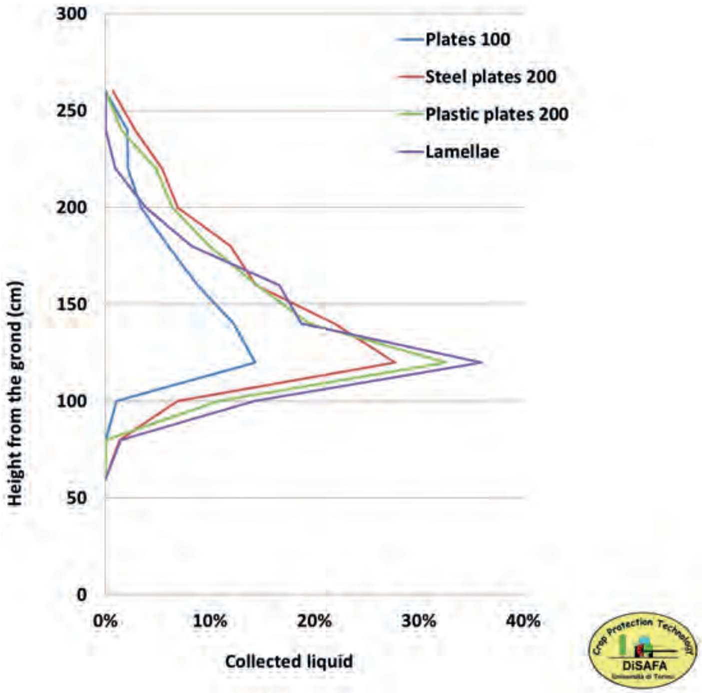

Fig. 14. Vertical spray profiles detected with the different vertical test benches examined when the conventional hollow cone nozzle TXB8004 combined with the air velocity of 8.2 m/s was employed and the spray unit was inclined 30° with respect to the vertical test benches.

The tests carried out enabled to acquire first experimental data about the performances of different vertical test benches, it is needed to carry out further investigations (e.g. using axial fans and nozzles positioned on semi-circular booms) in order to get more information about the behavior of vertical test benches in conditions closer to their use for air-assisted sprayer calibration.

Nevertheless these first experimental data could be useful for starting the development of a SPISE advice about "test methodology and requirements for vertical patternators".

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Acknowledgments

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Adjusting and Straightening the Air Distribution of Sprayers for Three Dimensional Crops:
The State of the Art

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Professional growers of both organic and integrated fruit and grapevine growing demand for a highly efficient spray application that allows the treatment of an area as large as possible per vat filling. This is the crucial key parameter to utilize limited time windows with climatical conditions, as e.g. low natural wind, suitable for the application of pesticides. Another key for modern fruit farms is the minimization of total time consumption for spray application, because they increase in size but only a few are big enough to employ staff apart from the family members, creating a strong pressure to save time for spray application in general. The time consumption for spray application is split up into

a) the time required for the preparation of the spray liquid and cleaning sprayers,

b) the time for driving to and from an orchard resp. vineyard and

c) the time for the application itself.

To meet both demands, a minimization of the water volume per hectare and the maximization of forward speed during spray application are the points of interest. This aim basically can only be achieved by small droplet nozzles combined with an adaptation of water volume to canopy characteristics and a canopy adapted forward speed, increasing as canopy width decreases. Small droplets offer a range of other important benefits to the grower as there is the low risk for phytotxicity of pesticides and leaf fertilizers, the low risk for visual deposits on the target and the controllability of their behaviour by an air stream. Since small droplets contain a high risk for drift, means that successfully reduce spray drift of small droplet nozzles have been developed in recent years and have been officially registered by German and Austrian authorities. These means are a combination of

a) fans with cross flow characteristics to minimize vertical spray drift above the canopies into the atmosphere,

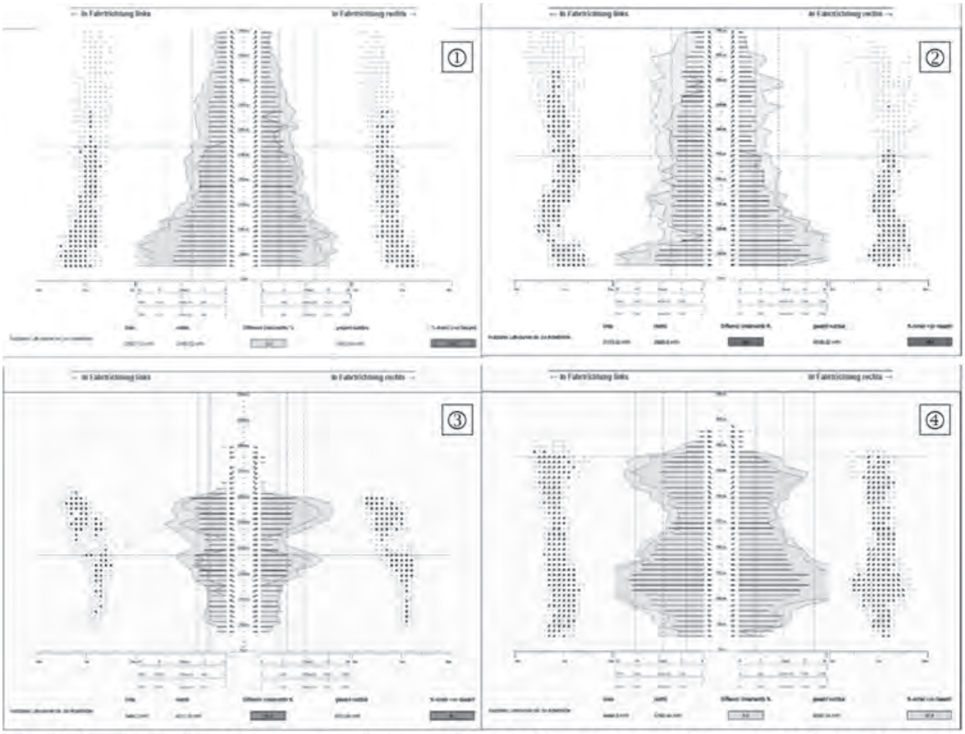
b) an adaptation of fan speed to canopy width at any forward speed in order to prevent the spray mist exiting the canopy at the opposite side and moving across the next alley way or out of the orchard,

c) a combination of air induction nozzles at the two top most positions and small droplet hollow cone nozzles in any other positions and

d) dosing models that calculate not only dose rate and water volume in relation to canopy characteristics, but also forward speed and in the future even fan speed.

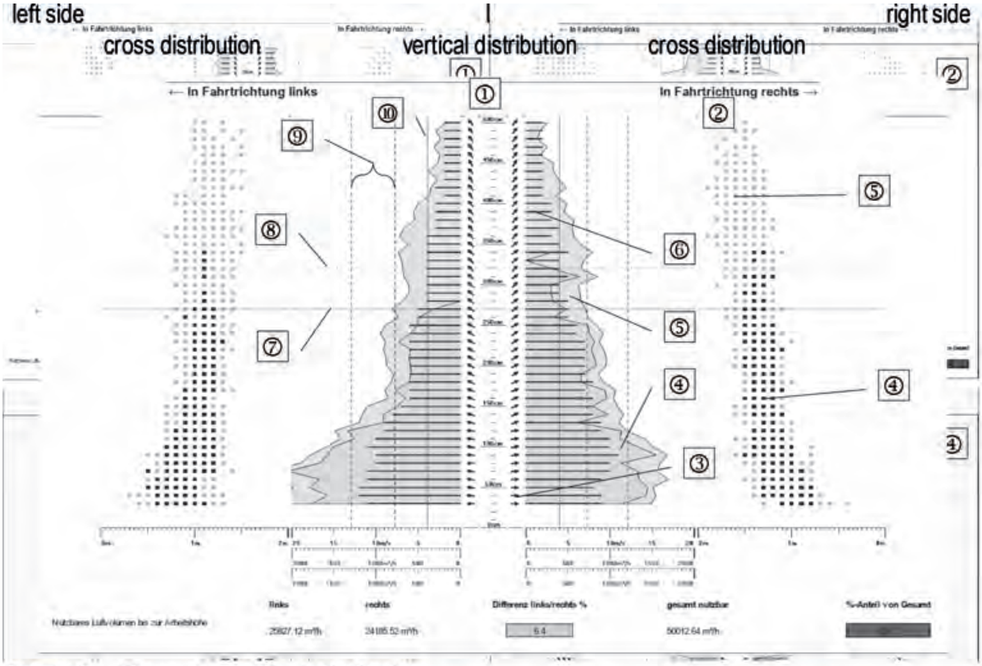
A basic obstacle for the adaptation of fan speed to canopy width has been the vertical air distribution of fans since in the past this was not taken into account at all for orchard and vineyard sprayers, because a high air volume and low forward speed have been assumed to be essential for good penetration into the canopy and good spray cover. Accordingly first measurements of the air distribution disclosed very uneven air distribution patterns which result in a very uneven horizontal reach of the air stream over working height. The result of such an uneven distribution is that in practice fan speed is increased until the spray mist from the section of the fan with the lowest horizontal reach sufficiently penetrates the canopy for the successful control of pests and diseases. At the other sections of the fan the horizontal reach consequently becomes far to strong, shooting the droplets through the canopy and high into the atmosphere. Keeping the droplets mostly inside the canopy by a canopy adapted fan speed, increases deposition efficiency significantly and offers the chance of reducing dose rates related to canopy characteristics without decreasing spray cover and a reduction of biological efficacy. Contrary to the wide spread opinion an excessive fan speed has remarkable detrimental effects on the efficiency of spray deposition in relation to water volume sprayed and the quantity and quality of spray deposits, is the main reason for avoidable spray drift from small droplets and increases fuel consumption and noise emission, of which at least the far distance visibility of spraying with an excessive air stream and noise are main causes for increasing complaints from bystanders and settlement areas. But also retailers and environmental organizations demand for the development and utilization of means to reduce contamination of non target areas and the CO_2-footprint of agricultural production. With a sprayer having an uneven air distribution, in the end fuel consumption and noise emission have to be raised in order to compensate a poor vertical air distribution, undoing all the benefits a canopy adapted fan speed offers for efficient and environmentally more friendly spray application.

As a defective vertical air distribution (**graph 1**) has been identified to be the key parameter preventing the introduction of a canopy adapted dosing and spray application, in 2010/11 the “Kooperation der Regionen”, a cooperation for improving, testing and adjusting air distribution of orchard and vineyard sprayers has been founded by the “Styrian Professional Fruit Growers Association”, the “South Tyrolean Advisory Board for Fruit and Vine Growing” and the “Marktgemeinschaft Bodenseeobst eG”. Also a new air test bench using ultrasonic sensors has been developed and installed in the three regions at Gleisdorf, Austria, Lana, Italy and Friedrichshafen, Germany.



Graph 1: Examples of poor vertical air distribution: ①= axial fan, ②= tower sprayer, ③= tower sprayer, ④= twin fan

In 2013/14 the performance of the test bench itself has been improved to increase work rate and the two page protocol has ben reengineered. It now contains a graphical display of the vertical air distribution of both fan sides and a dot graph of the cross distribution based on a 100 x 100 mm resolution of the sensor. The graph of the vertical air distribution shows the angle of the air stream at each vertical measuring position, but also maximum speed and the air volume above a threshold level of speed and volume, defined as the usable air volume. The maximum variation of the usable air volume over working height is secured by a threshold value of a coefficient of variation. A second air volume between the threshold level for the usable air stream and a threshold for the speed of ambient air, defined as non usable air volume that does not reach the canopy during spray application is also displayed. To adjust the vertical air distribution as close as possible to a rectangular shape and to offer a guidance for the adjustment of the air distribution to maximum tree height to be sprayed with the indivdual fan, a corridor over working height is displayed in the protocol, calculated from the average value of usable air volume over working height, a threshold for maximum positive and negative deviation and a maximum percentage of measuring heights over working height with the usable air volume located outside the corridor. The working height is automatically calculated by the test bench as the height above which on either fan side on two or more neighbouring measuring heights a minimum of usable air volume has not been recorded, being marked by a first horizontal line. Half a meter above working height a second horizontal line is displayed, defining the upper limit up to which the air support should be cut off in order to keep the potential for vertical spray drift above the canopy as low as possible. Both values of non usable air volume above working height are secured by individual maximum percentages of total air volume. Additionally the difference of the usable air volume between left and right fan side should not exceed a certain threshold level as well as the ratio between non usable and total air volume (**graph 2**).

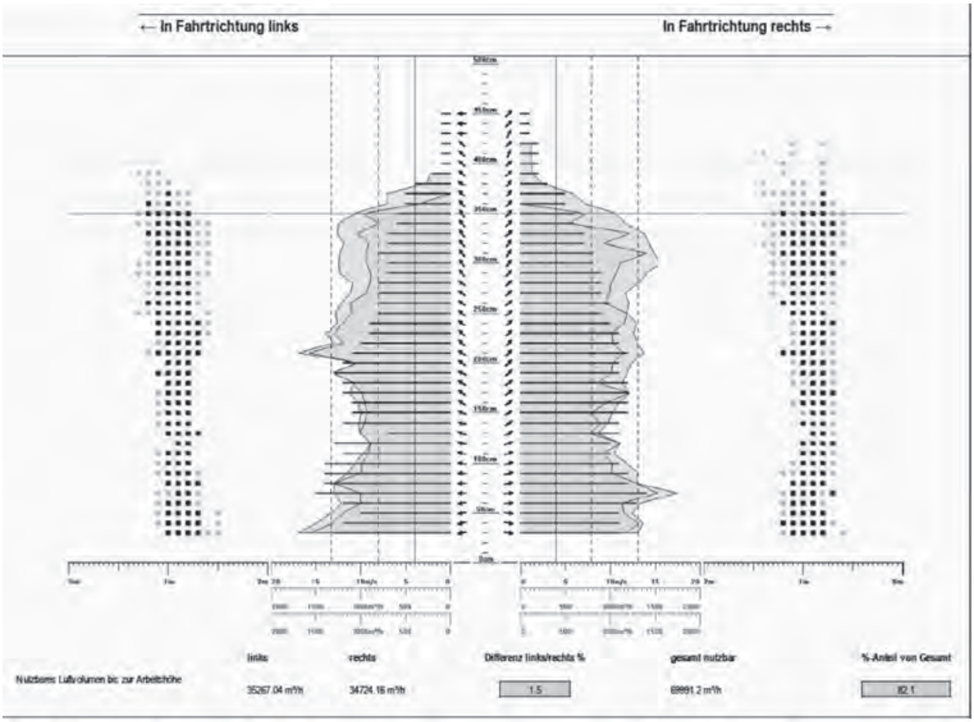


Graph 2: Protocol, page 2: air distribution

①= vertical distribution, ②= cross distribution, ③= angle air stream, ④= usable air volume, ⑤= non usable air volume, ⑥= maximum wind speed, ⑦= working height, ⑧= target vertical cut off air stream, ⑨= dynamic corridor usable air volume, ⑩= minimum speed usable air volume

Detailed information about the result calculated for any parameter is displayed on page 1 of the protocol and is coloured in green if the parameter meets the threshold value and in red if it does not. A fan has passed the test when all parameters stay within their threshold values resp. all fields are coloured in green (**graph 3**).

The threshold values for automated judgement of the air distribution are defined by the working group “Kooperation der Regionen” consisting of the three test bench operators, which developed guidelines of an air distribution suitable for “Low Loss Spray Application” in agreement with sprayer manufacturers participating in the “Low-Loss Spray Application” concept on an annual workshop. To enable potential customers finding out which fan types meet the demands of “Low Loss Spray Application” at the farm specific maximum working height, a positive list of fan types is published and updated according to demand. A fan type listed there is approved to meet the guidelines of “Adjusted Air Distribution ” or “Low Loss Spray Application”. Even when being listed in the positive list, any individual new sprayer with the same fan type as listed needs to be adjusted before purchase, because it is impossible to manufacture a series of fans with the same vertical air distribution. However, this is also not necessary, as long as the fan is adjustable – which is the case when the fan is on the positive list - because the air distribution anyways needs to be adjusted to the farm specific working height and then straightened to approach the rectangular vertical air distribution as good as possible.



Graph 3: Vertical air distribution of a tower sprayer meeting the guidelines of Low Loss Spray Application

The protocol also contains "environmental data" about energy consumption and specific energy consumption at three defined fan speeds from the fan type tests for the positive list, enabling the comparison of the energy efficiency of fans from various manufacturers. Environmental data are completed by noise measurements also at three fan speeds.

With the positive list and the environmental data potential customers are informed prior to ordering a sprayer about basic features of fans from various manufacturers. After a customer has chosen the fan type most suitable for this farm specific needs, the vertical air distribution is to be adjusted to farm specific working height and the air volume straightened before purchase. To avoid an accidental change of positions of deflection plates during delivery and use, they are permanently fixed after the adjustment. Fixing of deflector plates is absolutely necessary, since the vertical air distribution is extremely sensitive to even smallest changes of just millimeters of the orientation of the deflection plates and other obstacles in the air system. In case the fan cannot be adjusted to the desired working height or does not pass the test, it is returned to the manufacturer and the contract of purchase becomes void.

With this system of the three important fruit growing regions cooperating in testing and adjusting the vertical air distribution of sprayers for three dimensional crops, growers have the guarantee to buy a sprayer with a fully functioning air support that provides a uniform horizontal reach of the air stream over farm specific working height after successfully being adjusted to the tree height at the customer´s farm. With the uniform rectangular air distribution, proven by a protocol from before and after the adjustment the grower may make use of basic benefits of canopy adapted spray application, as there is an improved spray deposition and a reduction of fuel consumption and noise emission. When following the more strict rules of "Low-Loss Spray Application" the grower may additionally combine the high work rate of low volume spray application with an effective drift reduction enabling the utilization of reduced buffer zones to water courses, the reduction of pesticide consumption on a farm level by canopy adapted dosing and spray application, avoid visual deposits, minimize the risk for phytotoxicity and significantly reduce time consumption and costs of crop protection.

Session 7: Definition of a common risk assessment procedure for Pesticide Application Equipment (PAE) to be exempted from the inspection (TWG 2)

Results of the enquiry carried out on the NAP of the MS about the PAE to be exempted from the inspection and about the Risk Assessment methods applied.

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Summary

The European Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use of pesticides sets rules to reduce the risks and impacts of pesticide use on people's health and the environment. The Article 4 of this Directive requests the Member States (MS) to adopt a National Action Plan (NAP) to set up their quantitative objectives, targets, measures and timetable to reach the Directive's objectives.

Article 8/3 of the Directive allows the MS to derogate from the mandatory inspection at regular intervals for certain types of pesticide application equipment (PAE). The derogation is based on a risk assessment for human health and environment and an assessment of scale of use.

The purpose of this paper is to report on an enquiry carried out on the NAPs about the PAE to be exempted from the inspection and about the risk assessment methods developed and applied by the MS.

Introduction

Article 8/1 and 8/2 of European Directive 2009/128/EC on the sustainable use of pesticides establish the main scope of the mandatory inspection in EU. Covering all types of Pesticides Application Equipment (PAE), this scope is extremely large.

Article 8/3 allows the Member States to derogate from the mandatory inspection at regular intervals of certain types of pesticides application equipment (PAE) based on a risk assessment for human health and environment and an assessment of scale of use. The FWD does not give any clear instruction and/or indication on these assessments. Nevertheless the MS will have to carry out these ones if they want to introduce derogation and without having a clear protocol, an uneven situation may occur within the MS.

During the SPISE 2009 and 2012, the discussion about this subject led to the conclusion that:

- Specific and standardized protocol for Risk Assessment doesn't exist,
- MS haven't defined the PAE list of derogation,
- Common sprayer Risk Assessment methodology is recommended,
- It seems that EU and MS take a low interest in that matter.

However Article 4/1 of the Directive requests the MS to adopt a National Action Plan (NAP) explaining how they intend to reach the Directive's objectives. Indeed, MS have different available resources. This means that they could follow distinctive paths to meet the requirements and obligations of the Directive. In their national action plans, they explain how they intend to do this.

The NAPs might be communicated by 14 December 2012 to the Commission and are available on the DGSanco website (Health and Food Safety). A survey has been conducted on the available NAP, aiming at collecting the information and/or decision given/taken by the MS about the derogation from the PAE inspection and the Risk Assessment.

Results and discussion

The NAPs of the 28 MS have been uploaded, read and analyzed. The five following questions have been posed and the answers have been found in the NAP.

1. Which MS mention a notion of derogation in their NAP?
   - 19 countries on 28 mention the notion of derogation (Notice that in Austria, the derogation has been mentioned in the NAP of only one Länder on 9: Burgenland),
   - Denmark, France, Germany, Greece, Lithuania, Poland, Slovenia and Spain don't refer to this derogation in their NAP.
2. Which MS consider the possibility to derogate from the inspection?
   - 16 countries on 19 agree on a possible derogation from the inspection,
   - Czech Republic, Romania and Slovakia reject the possibility of any derogation from the inspection.
3. Which PAE are considered by the MS to derogate from the inspection?
   - Knapsack sprayer: exemption Belgium,
   - Handheld PAE: exemption Portugal, longer interval (6 years) Luxembourg,
   - Lance sprayer: exemption Belgium,
   - Herbicides PAE in vertical crops: exemption Austria – Burgenland,
   - PAE with boom < 3 m: exemption Austria – Burgenland,
   - PAE not used for spraying PPP: exemption Portugal,
   - Estonia:
     - Longer interval (without precision): seed-treatment equipment and misting devices,

- o Sweden:
    - Different timetables and inspection intervals (without precision): equipment in greenhouses and for killing fungi on tree trumps,
- o UK:
    - Interval of no > 6 years (listed in annex 4 of the UK NAP): ground crop sprayer (< 3m), granule applicator, boat mounted applicators (< 3 m), boat mounted granule applicators, fogging-misting and smoking equipment, batch dipping equipment, seed treating equipment, conveyor-roller table-other moving equipment, sub-surface liquid applicator,
    - Other equipment may fall into this category.

4. Which MS mention the Risk Assessment in their NAP?
    - o 7 countries on 28 mentioned the notion of Risk Assessment in their NAP: Belgium, Croatia, Czech Republic, Estonia, Latvia, The Netherlands and Sweden.
5. Which Risk Assessment protocol is described in the NAP?
    - o Estonia gives a kind of Risk Assessment which is based on an inquiry done in 2010 on the use of plant protection equipment in the country.
    - o Belgium returns to the European Commission the responsibility to develop and describe the Risk Assessment protocol.

Conclusion

The enquiry carried out on the NAPs allows evaluating how so far the MS are involved in the issue of the derogation and the related Risk Assessment methods requested by the Directive 2009/128/EC.

The results show clearly that the MS doesn't feel concerned by the derogation and certainly not by the Risk Assessment.

On one hand, some MS don't refer at all to the derogation in their NAP, taking for granted that the entire Directive's scope is covered by their actual Inspection Scheme for sprayers. It is difficult to define if these countries misunderstood the requirements of the Directive or if they made confusion between the sprayer and the PAE.

On the other hand, the MS, having established a PAE list for derogation, don't justify how, why and on what grounds they could derogate these PAE from the inspection.

Finally, the Risk Assessment concept doesn't meet a real success with the MS. It highlights the fact that this requirement isn't clear and isn't a priority for most of the MS. COM didn't give clear indication/instruction on this risk assessment and the priority in many Member States is at least to start the inspection of boom and orchard sprayers before the end of 2016.

However, the Article 8/3, by introduction derogation possibilities, makes lighter the implementation of the Directive, considering the MS particularities and the unavailability of standards or valuable protocols.

Sprayer inspection parameters as a basis for risk assessment for human health and the environment

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Introduction

Article §8 (3) of Sustainable Use Directive (SUD) provides a risk assessment for human health and the environment in order to apply different time tables and inspection intervals in selected cases for the inspection of pesticide application equipment (PAE) in use. These exemptions are concerning PAE

- not used for spraying pesticides,
- which are handheld application equipment,
- knapsack sprayers,
- or additional PAE that represent a very low scale of use.

In this context the question arises with which methodology such a risk assessment could be done following practical and professional consideration. Some general aspects concerning this topic were already presented by Ganzelmeier (2012).

The risk matrix according to Nohl and Thiemecke (1988) is a common method for technical risk assessment also known as Zürich-methodology. It is applied for the assessment of safety risks of aerial railways or even for the assessment of risks arising from the operation of nuclear power plants. A technical risk is the product of probability of occurrence of a certain failure and the extent of the subsequent damage. These two elements of a technical risk can be presented in a matrix distinguished in different qualitative classes (Fig. 1). Aim of the matrix is to define how high a risk might be.

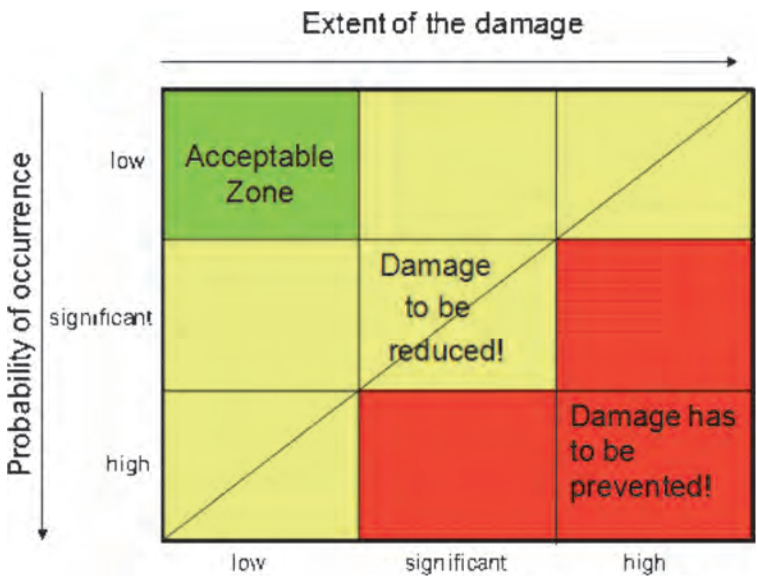

Fig. 1. Risk matrix according to Nohl and Thiemecke (1988).

The advantage of the Zürich-methodology concerning the risk assessment of PAE is that the risk assessment can be reduced to those technical parameters which are the focus of the inspection of PAE in use. This means that parameters being fraught with risks could be eliminated by inspection for that pesticide application equipment being obliged to inspection. Aim of this contribution is to present and discuss the basic necessities being mandatory for the potential use of the Zürich-methodology in the context of risk assessment for PAE in use in order to achieve a consistent risk assessment methodology within the EU member states. It will be shown how a risk assessment could be done in order to achieve an equal treatment of all PAE on basis of the SUD. Moreover, open questions which need to be discussed by the experts will be elucidated.

Material and Methods

In order to use the Zürich-method for the question of sprayer inspection the extent of damage and the probability of occurrence have to be determined. The extent of damage can be discharged by a qualitative analyses of equipment components being part of the inspection (acc. EN 13790) and their impact on human health and the environment. Therefore, each category of PAE is judged about the impact of their different components by using qualitative measures (Tab. 1). Afterwards, the qualitative results are quantitated by using a point system: ++ = 20 points, + = 15 points, 0 = 10 points, - = 5 points and -- = 0 points. Accordingly, the sum of each category is formed. For the axis describing the probability of occurrence within the risk matrix, at the end the categories are ordered by size (cf., Fig. 2).

Tab. 1. Different categories of Pesticide Application Equipment and the qualitative impact of their components on human health and the environment (++ = very high, + = high, 0 = average, - = low, -- = very low).

Pesticide Appl. Equipment (PAE) / Equipment components	spraying (incl. fogging)	hand-operated	not used for spraying	handheld	knapsack sprayers	additional	additional/ train	additional/ aircraft
Power transmission parts	++	+	0	--	--	0	+	+
Pump	+	+	+	0	0	0	+	+
Agitation	+	+	0	--	-	-	++	++
Spray liquid tank	++	+	+	--	--	+	++	++
Pipes and hoses	+	++	++	--	--	0	++	++
Spray boom	+	0	0	--	--	-	+	++
Filter	0	0	0	-	-	0	0	0
Nozzles	++	++	+	-	-	0	++	++
Controls	0	0	0	-	0	0	+	+
Regulation systems	+	0	0	-	-	+	++	++
Distribution / drift	+	0	0	-	0	0	++	++
Cleaning	++	0	0	-	-	0	++	++
Blowers	+	-	-	-	-	-	-	-
	205	165	150	45	60	125	215	230
	⑥	⑤	④	①	②	③	⑦	⑧

The probability of occurrence can be figured out by taking the number of incidents of each group of PAE into account. Unfortunately, there are no such statistics available on a national level of all member states. This lack of information can be solved by taking the number of different PAE used in practice into account, since this is proportional to the frequency of incidents. For these figures even rough estimations could be a basis for this qualitative approach. In the following six different kind of probability of occurrence-levels were chosen according to the following numbers of PAE in use: level 1 = 1,000 PAE, level 2 = 2,000 PAE, level 3 = 5,000 PAE, level 4 = 10,000 PAE, level 5 = 20,000 PAE, level 6 = 50,000 PAE.

In the next step the discharged extend of damage and the defined probability of occurrence-level are registered in the matrix (Fig. 2). The risk is calculated by multiplying the extent of the damage (1-8) with the probability of occurrence-level (1-6) throughout the whole matrix.

Extent of the damage →

Pesticide Appl. Equipment (PAE) / Probability of occurrence - level -		① handheld	② knapsack sprayers	③ additional / low scale use	④ not used for spraying	⑤ hand-operated	⑥ spraying (incl. fogging)	⑦ additional/ train	⑧ additional/ aircraft
1	(1´)	1	2	3	4	5	6	7	8
2	(2´)	2	4	6	8	10	12	14	16
3	(5´)	3	6	9	12	15	18	21	24
4	(10´)	4	8	12	16	20	24	28	32
5	(20´)	5	10	15	20	25	30	35	40
6	(50´)	6	12	18	24	30	36	42	48

Risk tolerance = 12

( ) number of PAE in thousands

Fig. 2. Risk matrix with calculated risks for each point of the matrix.

To determine the risk tolerance line which defines the difference between those risks which are tolerated (= exemption on inspection) and those which are not tolerated (= no exemptions on inspection) some basic ideas of the SUD have to be taken into account in order to have an equal treatment of all PAE.

Article 8 (3a) designates the categories "spraying (incl. fogging)", "train" and "aircraft" as being mandatory for inspection. This means that they have to be underneath the risk tolerance line. On the other side article 8 (3b) exempts "handheld PAE" and "knapsack sprayers" from inspection, if operators are trained. Taking the discharged risk matrix into account means that the highest risk which can be tolerated without inspection is at the level of 12 (Fig. 3).

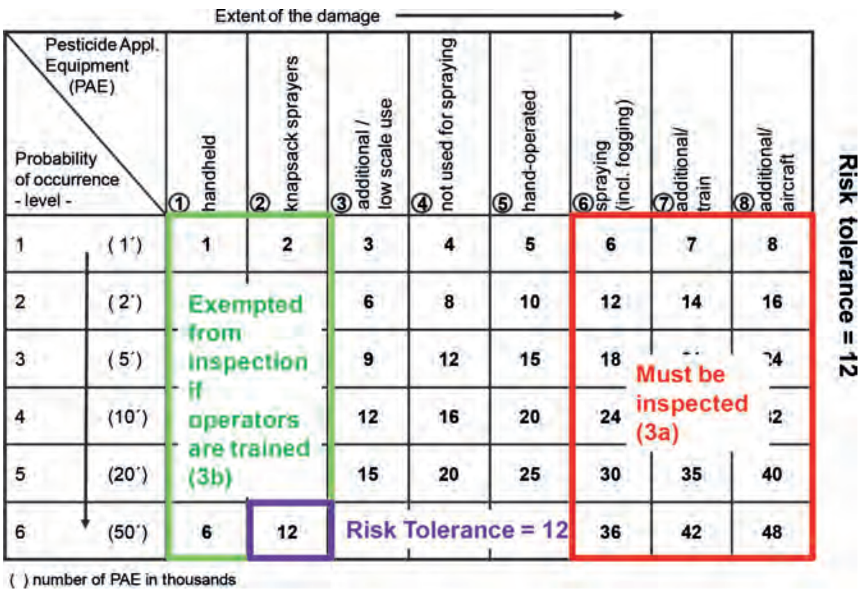

Fig. 3. Risk tolerance based on Sustainable Use Directive (SUD).

Results

The stated risk tolerance line in Fig. 4 divides all the risks being higher as 12 from those which are smaller. There are four exceptions within the categories "spraying (incl. fogging)", "additional/train" and "additional/aircraft" (second and third line). The reason why these are within the red zone is because these categories are as mentioned mandatory for inspection. The green zone represents all PAE which are exempted from inspection according to SUD §8 (3b), if the operators are trained. The yellow zone defines those cases where different time tables and inspection intervals can be applied.

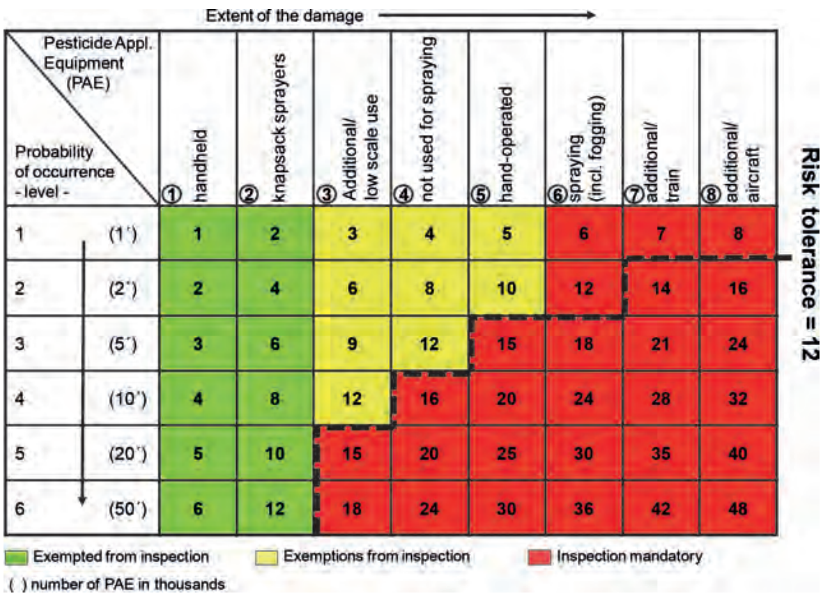

Fig. 4. Risk matrix for the need of inspection of different categories of PAE.

Discussion

The risk assessment can determine which type of the relevant PAE has a low, a significant and a high risk with regard to human health and the environment from a technical point of view on a qualitative measure. It cannot judge the risk which is coming from unprofessional use of PAE by the operator. But since we are talking about the necessity of an inspection for certain categories of PAE and inspection does not train the operator, the risk of use cannot be the question.

The presented methodology just takes those technical parameters into account, which are components being proved by inspection. This approach limits the area of consideration concerning the risks to that one which can be suppressed by a technical inspection. Furthermore, it puts the same criteria to all categories of PAE so that all of them are treated in an equal way concerning the question if exceptions from inspection are needed or not.

The risk assessment presented here is a qualitative one. It is lacking in accuracy at different steps of the approach due to subjective measures or due to a lack of information which are not existent and could maybe only be roughly estimated. The question is if a more sophisticated approach would really come up with another ranking of the PAE categories as shown in Tab. 1 and Fig. 2? What is needed in any case is that an expert panel confirms the qualitative judgment made in Tab. 1 and gives a written statement about the specific evaluation of each point which clearly informs about the estimations made. Further questions which need to be discussed among the experts of the member states is if the numbers used for probability of occurrence-level are the right standard or not and are their statistics or at least rough estimation available on the level of the member states about the number of relevant PAE in use.

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Development of a harmonized risk mitigation toolbox dedicated to environmental risks of pesticides in farmland in Europe: outcome of the MAgPIE workshop

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Abstract

Risk mitigation measures are a key component in designing conditions of use of pesticides in crop protection. A 2-step workshop was organized under the auspices of SETAC and the European Commission and gathered risk assessors and risk managers of 21 European countries, industry, academia and agronomical advisors/extension services, in order to provide European regulatory authorities with a toolbox of risk mitigation measures designed to reduce environmental risks of pesticides used in agriculture, and thus contribute to a better harmonization within Europe in the area.

The workshop gathered an inventory of the risk mitigation tools for pesticides being implemented or in development in European countries. The inventory was discussed in order to identify the most promising tools for a harmonized toolbox in the European area. The discussions concerned the level of confidence in the technical data on which the tools identified rely, possible regulatory hurdles, expectations as regards the implementation of these tools by farmers and links with risk assessment. Finally, this workshop was a first step towards a network gathering all stakeholders, *i.e.* experts from national authorities, research sector, industry and farmers, to share information and further develop this toolbox. This paper presents an outline of the content of the toolbox with an emphasis on spray drift reducing techniques, in line with the discussions ongoing in the SPISE workshop.

Key Words: pesticides, risk management, risk mitigation, Regulation (EC) No 1107/2009, spray drift reducing technologies.

Introduction

Risk mitigation measures are a key component in defining the conditions of use of pesticides in crop protection[1,2]. Risk mitigation tools are therefore of increasing importance in modern agricultural practices as well as in the revised legislation regarding their placing on the market[1]. In Europe, risk mitigation measures are recommended for ca. 95% of active substances during the regulatory peer review, and range from special protections while handling the product to conditions of use that allow to minimize transfers to groundwater, for example[1] (Tab. 1). These risk mitigation measures derive directly from the evaluation of pesticide products and the risk assessment conducted for each use, and are thus reported in the approval regulations for an implementation in European Member States[3]. For example, the registration regulation for the active substance spinosad dating 2007 recommends that Member States, in their assessment to authorize plant protection products containing the substance, to "*pay particular attention to the protection of aquatic organisms; conditions of use shall include risk mitigation measures, where appropriate*".

Tab. 1. Recommendation for risk mitigation measures as an outcome of the European risk assessment of pesticides. Compilation based on 290 active substances approved, excluding micro-organisms[3]

Nature of the risk to be mitigated	% of active substances concerned
Operator	42
Consumers	15
Groundwater	37
Surface water	26
Air	2
Terrestrial vertebrates	29
Non target arthropods	8
Soil organisms	8
Honey bees	8
Non target plants	9

The implementation of risk mitigation measures thus raises multiple exchanges between regulatory authorities, and a number of initiatives have been undertaken in order to develop and implement risk mitigation measures and where possible take them into account in risk assessment procedures. The harmonization of the risk mitigation measures implemented amongst countries is the primary issue, as the measures taken often relate to national policies in first place, as for example in France with the management of spray drift[4]. National policies also inform about the implementation routes for risk mitigation measures, which range from incentive measures, flexible for regulators and usually preferred by farmers, to legal enforcement, less flexible but perceived as more persuasive and therefore efficient in some countries. Finally, the interpretation of a recommendation in a regulatory text and on product's labelling varies among farmers as well as in the regulatory population and more harmonization and or clarity is deemed necessary in the wording associated to risk mitigation tools.

In this context, a 2-steps workshop was organized in 2013 under the auspices of the Society of Environmental Toxicology And Chemistry (SETAC) and the European Commission, in order to provide European regulatory authorities with a toolbox of risk mitigation measures designed for the use of pesticides for agricultural purposes, and thus contribute to a better harmonization within Europe in the area. The workshop gathered risk assessors and risk managers of 21 European countries including Norway and Switzerland, industry, academia and agronomical advisors/extension services. The discussions focused on environmental risks, of all nature: wildlife including vertebrates and invertebrates, flora and microorganisms, biodiversity as well as surface- and groundwater quality, identified as protection goals in the European regulation on pesticides[1].

During this workshop, an inventory of the risk mitigation measures used to reduce spray drift in European countries was performed and discussed as regards their effectiveness, their implementation in European countries and margin of improvement, and future developments. This paper presents an outline of the content of the toolbox with an emphasis on spray drift reducing techniques, in line with the discussions ongoing in the SPISE workshop.

Experimental methods

During the pre-workshop period an inventory of existing risk mitigation measures in European countries was undertaken. Eleven questionnaires were sent to participants, in order to collect feedback on the risk mitigation tools already implemented, their legal status (*i.e.* enforced via a dedicated legislative text, incentives or as part of good practices) and where relevant the piece of legislation involved (European, national or both). Additional questions allowed to address the technical knowledge on which each tool relied, and the related data were collected and referenced. Feedback of Member States on the success of implementation of the tools was also collected. The consultation finally covered risk mitigation options being in development in each country, as well as the "wish list" of respondents on the risk mitigation measures they were "dreaming of" or at least considered as the most promising in the future.

The measures inventoried were classified into categories based on their nature, *i.e.* related to products application conditions, application equipment or farming practices. The benefits they represented were listed and the piece(s) of legislation where they belong was (were) reported.

The risk mitigation tools listed in the inventory were further discussed and ranked to reflect their importance as a risk mitigation tool as for today or for the future. This ranking was performed using the following criteria, for each tool:

Implementation/advancement level: from well implemented tools in countries to tools on which insufficient knowledge or confidence were available;

Regulatory aspects: regulatory status of the tool, from the straight implementation of a legislation in place to simple good farming practices, possible regulatory hurdles associated to a tool as well as options to resolve them;

Possibility to measure the efficacy of the tool;

Possibility to relate to the risk assessment, *i.e.* to develop a risk assessment that accounts for the risk mitigation tool quantitatively or qualitatively.

The areas of research and of future development of these tools were discussed and accounted for in the ranking exercise.

Results and discussion

The inventory listed a number of risk mitigation measures already implemented in European countries. It also revealed diversity in the tools in use, as illustrated in Tab. 2 below.

Tab. 2. Risk mitigation tools inventoried in European countries, Norway and Switzerland as a result of the MAg-PIE workshop, together with their benefits and related regulatory framework

Category	Risk mitigation Measure	Benefits	Regulatory framework
Product application rate, timing, frequency	Application rate, application frequency and interval between applications	Lower transfers to groundwater and surface water Reduces exposure of organisms in-crop and off-crop	Regulations 1107/2009[1] and 547/2011[2]
Application equipment	Low drift nozzles, shields, precision treatment etc	Reduces exposure of organisms in-crop and off-crop	Regulation 1107/2009[1], Directives 2009/128[5] and 2009/127[6]
Buffer zones	Non sprayed zone at the edge of a crop	Reduces exposure of organisms in-crop and off-crop	Regulations 1107/2009[1] and 547/2011[2], Directive 2000/60[7], Directive 92/43[8]
Field margins	Vegetated buffer zone	Reduces exposure of organisms in-crop and off-crop and provide habitat and food resource	Regulation 1107/2009[1] and 547/2011[2], Directive 2000/60[7], Directive 92/43[8]
	Multifunctional field margin	Reduces exposure of organisms in-crop and off-crop and provide habitat and food resource and mitigate effects on biodiversity	Regulations 1107/2009[1] and 547/2011[2], Directive 2000/60[7], Directive 92/43[8]
Compensation areas	Recovery areas (ecological focus areas)	Provide habitat and food resource and reduce exposure of organisms in-crop and pending on location in the farmland may reduce exposure of organisms off-crop	Regulations 1107/2009[1] and 547/2011[2], Directive 2000/60[7], Directive 92/43[8], CAP[9]
Dust drift reduction technologies	High quality coating, low dust drillers	Reduces exposure of organisms in-crop and off-crop	Regulations 1107/2009[1] and 547/2011[2]
Bee management	Bee hive removal or protection, application periods, information to beekeepers	Managed bees	Regulations 1107/2009[1] and 547/2011[2]

Content of the toolbox and current implementation

Modifications of the application conditions (rate, number, frequency and in some cases interval between applications) are often cited as the first measure that may be recommended to reduce pesticide exposure and Member states confirmed their use to reduce exposure levels in environmental compartments (soil, water) and various non-target organisms. The reason for this is that such modifications may easily be taken into account in risk assessment and then check if a simple modification of the conditions of use would be sufficient to mitigate risks. The nature of the modification to be considered, however, depends on the needs derived from the risk assessment. A reduction of the application rates or of the application frequency may limit the exposure of in-crop organisms as well as the amount of pesticide residues leaching from the treated area to groundwater, since the level of exposure is directly dependant on the amount of pesticide applied. Transfer routes off-crop involve more factors associated to the off-crop area itself (such as interception by vegetated areas, transfer of soil-bound or water soluble residues for example) that may significantly impact transferable residue amounts. Also, modifications of the application rate are difficult to recommend without a proper assessment of the product's efficacy at a lower rate, particularly with regards to resistance management. Thus recommendations as regards maximum applications rates remain limited and have often been decided at a national level for all uses of the product, or a European level[3]. Reductions of exposure of off-crop organisms, terrestrial or aquatic, when required, more often consider buffer zones, vegetated strips or drift reduction techniques.

The most common measures implemented in Member States are buffer zones, which aim to mitigate transfers via spray drift in the off-crop area. Buffer zones consist in non-sprayed bands of variable width, to be respected in the vicinity of the area to be protected. Buffer zones are defined during the evaluation process of pesticides according to Regulation (EC) No 1107/2009. They are thus product-specific and defined for the different uses/use rates of the product by a quantitative risk assessment. Countries either determine the exact buffer width that is necessary to get the safe level of spray drift deposition, or most often fixed buffer zone widths (e.g. 10, 20, 50 meters) are defined and attributed to the product and its uses. The buffer zones are then reported on the labeling[2,3] using a harmonized set of phrases describing the precautionary measures (SPe phrases) that must be respected during pesticide application.

As mentioned above, buffer zones are defined to specifically protect an off-crop area. This area may be a water body or any area hosting non-target organisms (in the context of Regulation (EC) No 1107/2009, non-target arthropods or non-target plants) located at the edge of the crop on which products are sprayed. Our inventory revealed a wide recommendation of buffer zones at the edge of water bodies in European countries (27 out of 27 feedback), whereas the use of buffer zones to protect other non-target areas such as non-target arthropods habitat and/or non-target plants, remains more limited (20 out of 27 feedback to protect non-target arthropods, 12 out of 27 feedback to protect non-target plants). The reason for this probably relies in the somehow different nature of these buffer zones. Buffer zones to protect water bodies are measured from the edge of the water body (usually the top of the bank of a stream) to the last boom of the sprayer, and are therefore partly or entirely outside of the crop. In comparison, the habitat of off-crop non-target organisms usually "starts" at the edge of the crop (although strictly speaking this habitat may also include the crop area itself) and therefore implies to locate the buffer zone inside the crop. The main hurdle to the implementation of in-crop buffer zones by farmers is the potential for side-effects of leaving a band of crop untreated with regards to potential pests/weeds' impact to the crop, and our inventory counted two countries only reported their implementation.

Field margins, composed of simple grass margins or of more complex plant mix composition, were identified as a promising tool although they remain poorly recommended in spite of their potential benefits (Tab. 2). Vegetated buffer strips dedicated to the reduction of run-off are reported in 12 out of 27 countries. Other types of vegetated areas exist that may provide habitat to wildlife, including vertebrates (birds) and invertebrates and seed mixes have been commercially developed. In the UK and Switzerland, guidance has been developed for the implementation and management of these margins by farmers[10]. The benefit of these margins is increasingly documented particularly as regards the multiple benefits that may be provided by each type of margin. An increased implementation of these margins in the future is expected, as a mean to specifically mitigate transfers of pesticides, enhance structural and functional biodiversity, but also because they are part of the recommendations of the CAP reform[9]. The description of the "ecological focus area" provided in the CAP reform list field margins, hedges, trees, fallow land, landscape features, biotopes, buffer strips, afforested and other relevant areas. These ecological focus areas should represent at least 5% of the arable area of the holding for farms with an area larger than 15 hectares (excluding permanent grassland), and rise to 7% in 2017. Some of these tools are already implemented in European countries as part of Agro Environmental Schemes (AES) and feedback on their efficacy to provide the benefit aimed for has been reviewed in the workshop. The implementation of the CAP is ongoing in European countries and the ways it complements/overlaps with the AES already in place are variable among countries. Further optimization of the land use by farmers has been researched during the workshop, particularly on the options to elaborate on the recommendations already in place with the CAP as regards land use when developing recommendations being more specific for the mitigation of pesticide transfers.

Specific protection areas are also defined in other pieces of legislation, such as the "Habitat" directive (Directive 92/43/EEC)[8] and the Water framework directive (Directive 2000/60/EC)[7], where pesticide applications should be avoided. Directive 92/43/EEC defines protection areas for the protection of wildlife. This directive may complement the risk mitigation measures derived according to Regulation (EC) No 1107/2009 in the case where the use of a product is restricted to certain periods in an area in order to avoid the reproductive period of birds, for example, while Directive 92/43/EEC defines areas where the use of products in general is to be avoided. Directive 2000/60/EC specifically deals with the protection of surface and ground water quality. The list of measures includes the implementation of protection areas around drinking water sources, which may in some cases overlap with the protection areas that are recommended in the conditions of use of pesticide products. The main difference relies in the fact that the restrictions to be applied in a protection area according to the Water framework directive concern all pesticide products while such recommendation is derived from Regulation (EC) No 1107/2009 it is product-specific and derive from a risk assessment.

The risk mitigation tools to reduce exposure to seed dusts during the sowing of coated seeds or pelleted/granular formulations are being developed by the European Commission and have been referred to during the workshop[11]. This dedicated toolbox involves specific driller equipments and formulation technologies to improve coating quality and reduce dust formation and drift.

Our inventory finally revealed a wide implementation of additional risk mitigation tools aiming at protecting managed bees, mainly honey bees, from exposure to pesticides. These measures are listed in Regulation (EU) No 547/2011[2] and were reviewed during the workshop. They involve restrictions during pesticide application particularly during the flowering period of the crop as well as beekeepers awareness and intervention to e.g. cover hives or take them away from the sprayed area. The workshop discussed these measures as regards their effectiveness in reducing risks to other pollinating insects and also on the possible overlaps/contradictions with other measures, such as the promotion of flowering species in the farmland for the benefit of biodiversity, which will be included in the proceedings.

Outcome of the inventory as regards spray drift reduction technologies

Application equipment such as low drift nozzles, shields and precision treatment remain scarcely recommended at the European scale, and are country-specific (12 out of 27 feed-back). Overall, they aim to reduce transfers via spray drift and thus the exposure of organisms and environmental compartments around the crop that receives the treatment. The main reasons for the current limited use of low drift spraying equipment are an insufficient knowledge on their efficacy among users and regulatory authorities, as well as questions about possible reduced efficacy of products when applied with low spray drift nozzles. The lack of availability of some of these equipments on the market also limits their use locally. Communication campaigns have been initiated to facilitate access to knowledge on these equipments as for example on low spray drift nozzles in Italy and the UK, with the first visible results[12].

On a regulatory point of view, the buffer zones defined to limit deposits of spray drift in the off-crop areas are most often defined without taking into account additional risk reduction technologies, such as low spray drift nozzles or special equipments. In part, data are lacking to take into account quantitatively the level of transfer reduction reached by the use of a shielded sprayer or by using precision applications, in a risk assessment. Low spray drift nozzles constitute the exception as they are being tested and certified for drift reduction rate they provide, and methods are available that measure the effect of the nozzle on droplet distribution size and deposition reduction in tunnels or in the field[13]. Low spray drift nozzles may therefore be considered in a risk assessment on the basis of the transfer reduction they allow to reach, as it is the case in Germany, where buffer zones recommendations take into account the utilization of low spray drift nozzles as part of the mitigation techniques. The drivers in Germany were that the contribution of each mitigation measure to risk reduction is well described based on experimental measurements and the use of these tools by farmers is monitored. This confirms that a more widespread implementation of low spray drift nozzles by farmers is also a key element to their quantitative inclusion in the risk assessment. It is likely that the verification of the effectiveness of low spray drift nozzles in use will eventually enter in the scope of the recommendations of Directive 2009/128/EC as regards technical inspection of sprayers. The benefits of the risk reduction technologies have been discussed during the MAgPIE workshop, together with the possible ways of optimization when using several of these tools concomitantly.

Conclusions

The MAgPIE workshop reached the following objectives: (1) gather a state of the art of the current knowledge and developments of risk mitigation measures for pesticides in EU countries and if available beyond Europe; (2) discuss risk mitigation practices and their future implementation and development together with experts from national authorities, research sector, industry and farmers; (3) discuss the links between risk assessment and risk management and on how to account for risk mitigation options in risk assessment and (4) build a network to share information to feed their respective actions.

A number of risk mitigation tools may be implemented in the context of Regulation (EC)

No 1107/2009 and multiple references in the text of the regulation allow this at the European and National levels. Regulation (EU) No 547/2011 may be expanded in future in order to account for the risk mitigation measures that have been identified during the workshop and for which no dedicated Specific Precautionary phrase (SPe) is available yet.

With regards to spray drift reduction technology, the MAgPIE inventory highlighted the important technological developments invested by manufacturers in this area and reviewed their potential effectiveness at reducing transfers and thus risks. These important technological progresses need to be transferred to the field and to users, so that users gain experience and confidence in these tools, and to facilitate the inclusion of these tools in the risk assessment models. An important communication effort towards farmers to encourage the use of drift reducing technologies in the field is needed, as well as concerted actions, involving all stakeholders to build on the feedback from the field and further develop these tools, so that they become part of good agricultural practices in future. Detailed recommendations are being developed in the proceedings of the MAgPIE workshop, together with implications and recommendations as regards monitoring, modelling, the protection of biodiversity and practical and regulatory implementation, to be published in 2015.

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Posters

Determination of the influence of the driving speed on the application parameters of orchard sprayers

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Abstract

Orchard sprayers with air transported fine droplets need an exact adjustment of the airflow and the spray nozzles in order to reduce the drift of pesticides. The adjustment is made on one hand side by the manufacturer and on the other hand side by the farmer in the orchard by choosing the tractor speed, the PTO shaft rotation speed and the pump pressure. For testing two test beds have been in charge in the region of Styria since almost 2 decades. One of them is able to measure the flow field in a vertical plane representing the tree row in a distance of approx. 1.5 m from the middle of the track. The second measures the water distribution in the same vertical plane. Both are stationary so that the influence of the driving speed can hardly be assessed. High driving speeds up to 12 km/h and the increasing height of the orchards impose additional uncertainties. This was the reason for the present research project, which was intended to investigate the influence of the driving speed. A new air flow measurement test bed has been build, which is able to measure the flow field also during tractor movement in the described vertical plane up to 5 m above ground. Four different sprayers have been investigated in an orchard with and without leaves by visual method for four different speeds to determine the optimal application parameters. The same sprayers have been tested with the moveable flow field test bed. Results show a reasonable correlation between the measurements for all investigated speeds. The differences between the sprayers are evident, nevertheless a method has been found to deduce the correlation between the stationary measurement and the optimal parameters for the orchard. So the stationary flow test bed can be directly used to develop sprayers.

Introduction

What you still can find up to now!

Fig. 1. Current pesticide application using orchard sprayers (to be improved!).

Solution: Resources-saving plant protection in wine crowing and fruit-production

Goals:

- sufficient plant protection substance on the leaves at the perfect time
- low costs (sprayer, tractor, fuel, maintenance, automation, low number of spraying processes, etc.)
- environmental acceptance: small driftage (to air and soil) low noise

environmental-friendly substances

small soil-compaction, -degradation

Needs:

- optimized spraying process
- fine droplets
- small amount of water
- well adjusted air flow (depending on distance between the lines of trees, height, tractor-speed, leafage)
- well adjusted nozzles (depending on substance mass per ha, tractor speed)
- acceptable meteorology
- small tractor-sprayer-tank weight
- correct choice and documentation of spraying processes (substances)

Suggested procedure:

- Data base supported selection and documentation of substances
- Usage of well-tested sprayers (airflow and droplet distribution)
- Sprayer adjustment for PTO shaft rotation speed, tractor speed, pump pressure, and the number and position of open nozzles for every spraying process!

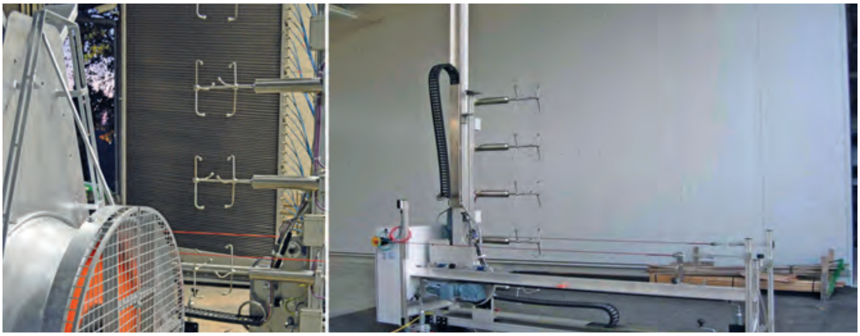
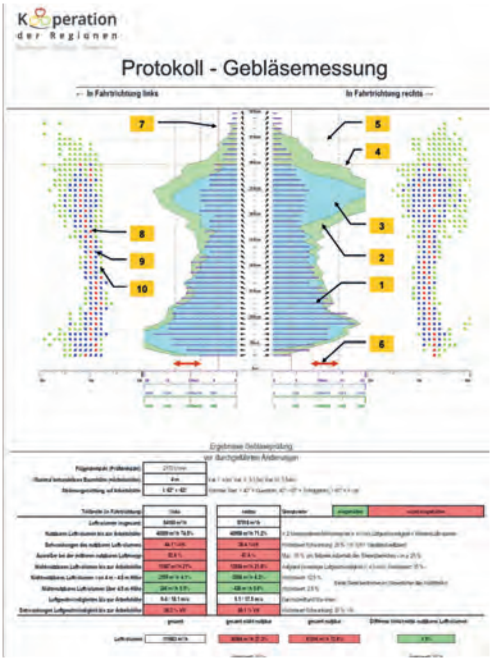


Fig. 2. Air flow test bed for orchard sprayers (equipped with 5 ultrasonic anemometers).

How to test orchard sprayers and how to find the best adjustment

Orchard sprayers with air transported fine droplets need an exact adjustment of the airflow and the spray nozzles in order to reduce the drift of pesticides. The adjustment is made on one hand side by the manufacturer and on the other hand side by the farmer in the orchard by choosing the tractor speed, the PTO shaft rotation speed and the pump pressure. In order to inform farmers about the status of their sprayer's two test beds have been in charge in the region of Styria since almost 2 decades. One of them is able to measure the flow field in a vertical plane representing the tree row in a distance of approx. 1.5 m from the middle of the track. The second test bed measures the water distribution in the same vertical plane. Both test beds are stationary so that the influence of the driving speed can hardly be assessed.



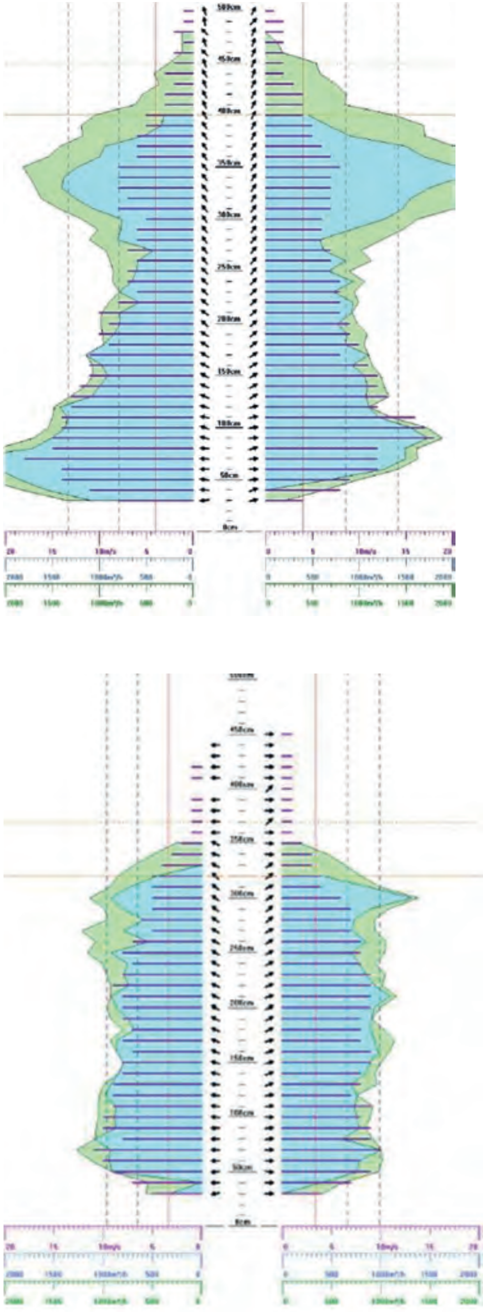


Fig. 3. Measurement protocols for the assessment of the air flow of sprayers.

The results of the air flow measurement are processed and presented in a protocol as can be seen in the following Fig. 3. The protocol shows air speed, direction, symmetry, total volume flow left and right side, etc. There are rigid rules to score the sprayers. Red boxes show a negative assessment. On the right hand side of Fig. 3 two results of the same sprayer without (above) and with (below) optimized air flow are shown.

Influence of the driving speed

Especially the high driving speeds up to 12 km/h and the increasing height of the orchards (up to 5 m) impose additional uncertainties. This was the reason for the present research project, which was intended to investigate the influence of the driving speed. A new air flow measurement test bed has been build, which is able to measure the flow field stationary but also during tractor movement in the described vertical plane in a distance of 1,5 m of the sprayer middle axis up to 5 m above ground. The following two pictures show the experiments, which have been carried out indoor in a hall. Four different sprayers have been investigated for the following three tractor speeds: 6, 9 and 12 km/h. The rotational speed for the sprayers have been found from visual investigations in the orchards.

Fig. 4. Test configuration for the air flow measurement with moving tractor.

In addition all four different sprayers have been investigated in different orchards with and without leaves applying a visual method for four different speeds to determine the optimal

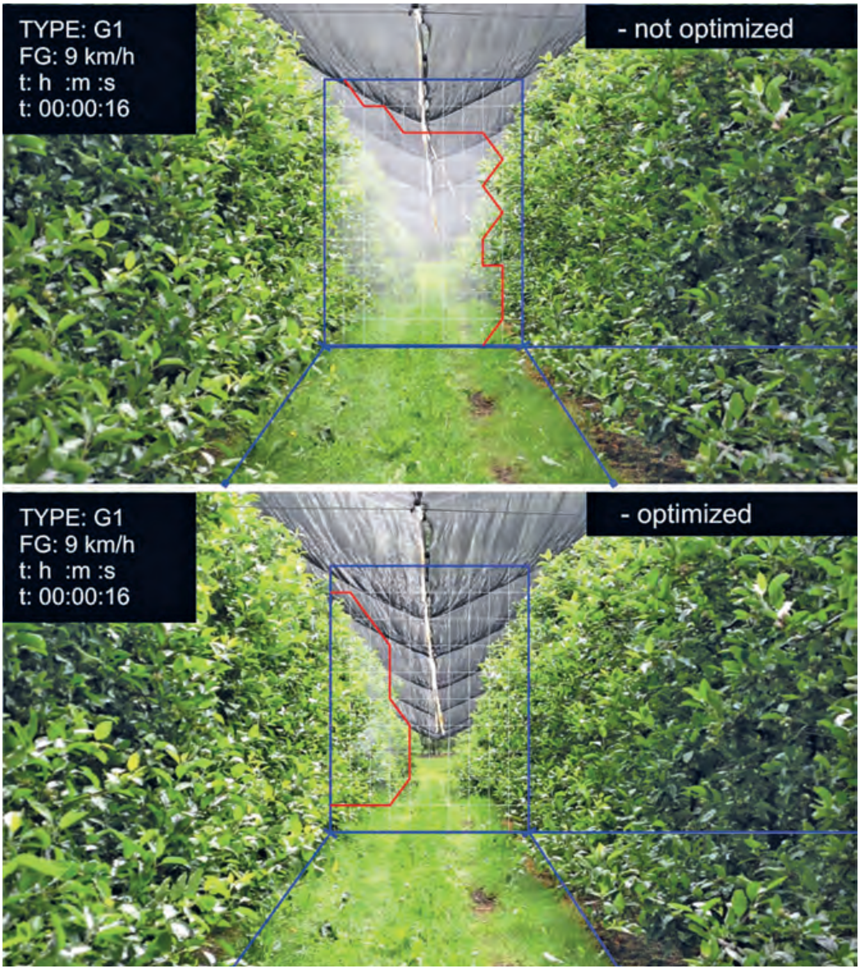


Fig. 5. Visual test of the sprayers in the orchard.

parameters for the pesticide application. The following pictures shows the droplet spray in the neighbouring driving lane. It shows that the driftage and a wrong adjustment of the sprayer can be easily detected in a backlight situation. Here it is to mention, that the sprayers are equipped with ant-driftage nozzles in the upper part of the air outlets.

The next diagram (fig. 6) shows the comparison of the results from the air flow test bed for stationary and in motion cases for all four investigated sprayers. The tests have been carried out for the optimum rotational speeds (U/min) for the individual sprayers.

It shows that an increase in tractor speed requires for the same penetration an increase in the rotational speed of the sprayer. Despite various equipment types, the differences between the devices are in practice negligible. The tests have been carried out for different foliage with a negligible influence on the spray distribution.

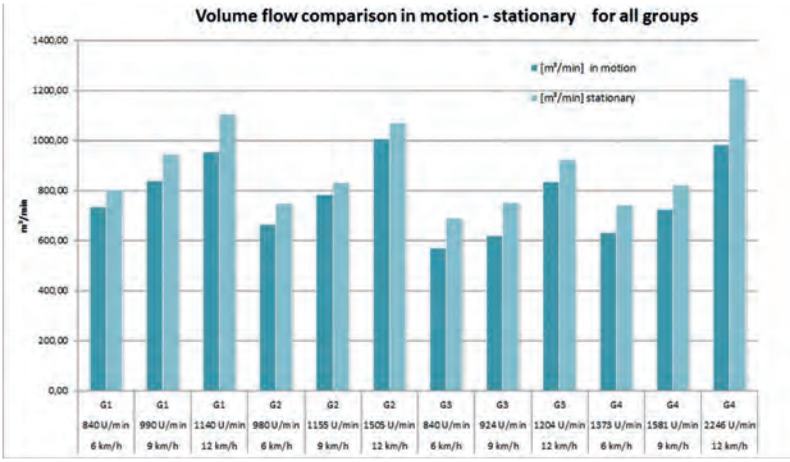


Fig. 6. Volume flow comparison in motion - stationary mean values.

The overall sprayers averaged air volume flow [m^3/min] runs mainly parallel between stationary measurements and measurements in motion. However, the shown curves include all the air speed values above 0 m/s. So they include also the rather turbulent flow between 0 to 1.5 m/s. If the turbulent portion is not taken into account, it results in a difference of air flow rates of around 8%.

Similar investigations have been carried out for smaller and larger row widths (2.8 m, 3.2m). The influences of the driving speed are reduced (2.8 m) or increased (3.2 m) as expected.

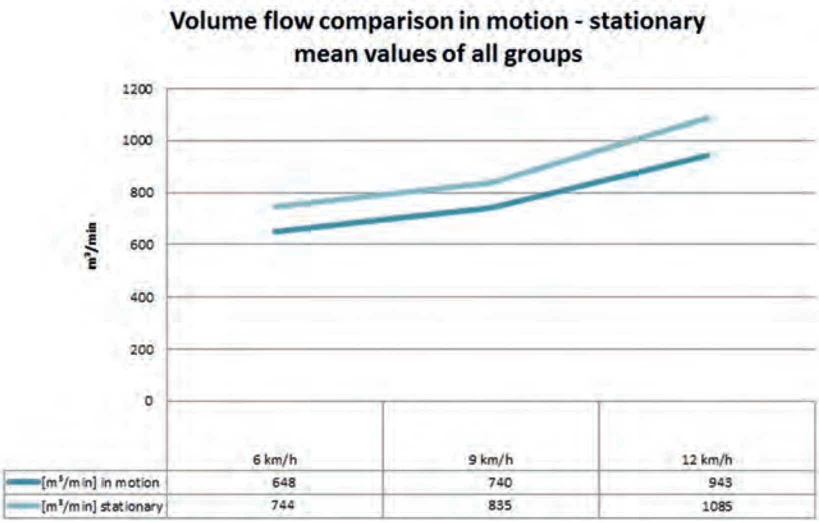


Fig. 7. Volume flow comparison driving-stationary - mean values of all groups.

Interpretation, discussion, and implementation

Stationary measurements of air flow rates on the test bed (fig. 2) are the most important basis of the research project. The results provide a profound picture of the air flow pattern in the vertical plane of the trees. The air flow test bed is already available in the following three regions: Styria (A), South Tyrol (I), and Southern Germany (Lake Constance). The main results of the measurement of a sprayer are summarized and shown in the protocol. The protocol and the whole method has been developed in co-operation of all three regions. This includes the criteria for inclusion in a so-called "positive list" where useful sprayers are recommended. This is done with the knowledge and in collaboration with the major manufacturers. In addition the test beds are compared in a round robin test and give reliable results.

Nevertheless the air flow test beds can only measure stationary and without droplets. This was the reason to set up a research project to investigate the influence of the tractor driving speed and the droplet-transport. The results show a stable correlation between stationary and in motion results for reasonable working conditions. These reasonable working conditions have been checked with visual tests in the orchards for four sprayers and three tractor speeds.

Another part of the effort in the research project has been put into the practical implementation of the results. For this purpose, the relationship between tractor speed, rotational speed of the sprayer (PTO speed), row width, row height, and sprayer type for each of the orchards is implemented in the application software "XComply". This information is now directly accessible for the farmer via smartphone or tablet. He receives the information about the allowed substances and the PTO speed of the selected blower for the requested tractor speed at the beginning of the application. The substances are documented and can easily be reported to the authorities

One major side-effect is the reduced noise as the PTO speed is generally rather low. Examples are given in measurement campaigns of the Bundesanstalt für Landtechnik Wieselburg, Austria, where the air flow of several sprayers have been improved to fulfil the above shown criteria (symmetry., speed, rectangular distribution over the height, etc.). There it was able to reduce the PTO-speed by up to 30% resulting in much smaller fuel consumption and noise emission.

No contract without positive air protocol

It is absolutely necessary to do something against the waste of pesticides and fuel. Therefore it should only be possible to use well suited environmental-friendly plant protection.

The steady-state measurement on the air test bed providing the measurement protocols are suitable for a decision support during equipment purchase. The claim must be raised that every sprayer has to comply with the above mentioned criteria - ie no contract without a positive air protocol!

The air flow criteria compliance of the sprayer is one of the final inspections which has to be done by the manufacturer. The criteria and the corresponding measurement technology are available on the market.

Links

www.sprayertest.org [Portal für die Sprühgerätekontrolle der Kooperation]
www.xcomply.info [homepage of the XComply project]
www.obstwein-technik.eu [Fachgruppe Technik vom Verband der Steirischen Erwerbsobstbauern]

Summary of Discussion Workshop on technical status quo and adjustment procedures of sprayers during implementation of IPM in Poland

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Introduction

All European Community member states were obliged to implement the 2009/128/EC Directive into national regulations and practice of Integrated Pest Management (IPM). The provisions of the Di-rective include, among others, compulsory testing of application equipment, and training and certifica-tion of all professional pesticide users, distributors and advisors. Some member states decided to imp-lement related procedures individually years ago, others left these aspects unregulated. Nevertheless, by December 2016, all 28 EC member states are expected to provide a system of procedures and infra-structure for control of spraying systems in use. With the large variety of crops, local agricultural practices, farming business models, and equipment used in crop protection, constructing efficient procedu-res is not an easy task . European Workshops on Standardised Procedure for the Inspection of Sprayers in Europe (SPISE) support the national efforts by providing a forum for experience exchange.

Assuring quality of the spraying equipment in use is only one side of the problem. It is necessary to take care of the training for the operators and advisors in crop protection. The success of IPM de-pends on their ability to plan a proper dosage of a right substance, and to precisely conduct the treat-ment to the maximum benefit of the farmer and the minimum loss to the environment. In this respect, selecting an optimal spraying system and its right settings are of key importance.

Situation in Poland

In Poland, a system of technical control of sprayers was established in 1999. More than 300 workshops received accreditation for mandatory testing of sprayers. Since the beginning of 2000, more than half a million sprayer inspections were conducted, most of them by means of mobile testing stations. Some of the accredited testing workshops work on seasonal basis (three months in early Spring and three months in Autumn). It certainly allows them to reduce costs, but the control of such testing stations with seasonal working system is much more difficult.

The Polish control system does not provide individual data on each sprayer. Only the number of conducted technical checks (with positive and negative result) is being monitored. For this reason is not possible to get information how many times each sprayer was tested. For the same reason, it is not possible to find out how many sprayers in the population were already inspected, and how many were never subject to tests. Moreover, there is a disturbing difference in the records on the numbers of sprayers in use. Two governmental institutions maintain their independent registers of sprayers. In 2010, the surveys of the Central Statistical Office of Poland (Główny Urząd Statystyczny - GUS) co-unted over 500 000 sprayers in use, and the Main Inspectorate of Plant Health and Seed Inspection (Państwowy Inspektorat Ochrony Roślin i Nasiennictwa - PIORiN) reported 330 000 sprayers in use.

With regard to standards on professional preparation of people involved in crop protection, Polish re-gulations set requirements only towards sprayer operators' training and knowledge. Crop protection competencies are not required from plant production managers. In practice, the operator is not the per-son to decide on the selection of pesticides or timing of the treatment. There were reported cases of a-nimal production specialists or agricultural economists taking decisions on plant protection treatments despite their lack of competencies in IPM. Some EC countries developed procedures that could be fol-lowed in Poland – for instance, requiring at least one IPM professional to be employed in a farm.

To meet the requirements of Directive 2009/128/EC in terms of spray boom working quality, two checks should be required: determination of cross liquid distribution and nozzle flow rates uniformity. Neither of them provides complete information of liquid distribution system quality, and they are in fact complementary. However, some countries selected only one of these checks as compulsory, and to transpose the Directive they need to change the regulations.

Spraying system nozzles offered on the Polish market as spare parts for agricultural machines are not subject to any requirements and any control, not even the PN-EN-ISO 12761-2 minimal requirement on spray drift control (§4.3.2. D_{v10} value higher than for reference 110° nozzle at 250 kPa and 0,72 l/min flow rate). There is also no control system of the nozzle spraying class. Some manufacturers cla-im that nozzles of different design but with the same flow rate according ISO 10625 visiflo color co-ding automatically belong to the same spraying class (as this parameter is required in pesticide labels). This information is then copied into brochures and manuals published by public institutions. However, there are no standards on the method of spraying quality class determination – so what exactly is un-derstood by the requirements given in the pesticide labels.

Moreover, technical information on nozzles stays without any control. Some technical sources, bro-chures, manual and electronic devices contain unverified data. Some procedure of nozzle quality con-trol is thus necessary, as there are many cases of inadequate quality of operation. Equipment without full operating guidelines should not be admitted to trading. It is also advisable that the manuals of PPP equipment, including spare parts such as nozzles, were unified under national regulations and PN/CEN and ISO standards.

The process of developing legislation and procedures of plant protection should not proceed without involvement of practitioners. These include not only spraying systems operators, but also sprayer sys-tem diagnosticians – experts with considerable experience not only with many designs of equipment available on the market, but also with the operating practices of their users.

Another group able to provide valuable input are advisors in crop protection and equipment suppliers; the Directive 2009/128/EC acknowledges their key role and requires that equipment suppliers should be trained in IPM just as plant protection advisors.

There are also concerns about machines not considered pesticide application equipment, but who-se operation poses risk of contamination, such as pneumatic seeders and planting machines. The pneu-matic seeder's exhaust air contains concentrated chemicals – a serious hazard for bees and surface wa-ters, so do planting machines with chemical treatment units. They are not covered by pesticide related regulations and not subject to control.

About workshop and participants

In first year of the IPM's Directive 2009/128/EC implementation, the Discussion Workshop was held in Poznań. The Section of Plant Protection Methods and Products (Committee of Plant Protection of the Polish Academy of Sciences) initiated this workshop in cooperation with the Committee of Ag-ricultural Engineering of the Polish Academy of Sciences) and Technical Committee (TC-16 – Trac-tors and machinery for agriculture and forestry) of Polish Committee for Standardization (PKN-KT-16) – CEN and ISO member. The workshop gathered over 170 participants: representatives of about 40 accredited sprayers testing stations, scientists and experts from ten research institutions. The dis-cussion was focused on the practical problems of IPM from the point of spraying system diagnosti-cians, operators, and advisors in plant protection.

Conclusions

Diagnosticians proposed their ways of improving the spraying system testing regulations. In par-ticular, the need for using both tests (flow rate and cross distribution) on spray boom operating quality was discussed. The liberal requirement for new sprayers – first mandatory check five years after pur-chase – was strongly criticized.

Another issue were the techniques of spraying at higher wind speeds – the recently eased regu-lations allow conducting treatments up to the wind speed of 4 m/s, but have not been accompanied by precise operating guidelines on spraying techniques and working parameters yet. The problem of lack of spray distribution standards and drift reduction technology classifications was vigorously discussed. The participants called for unification of international and national requirements in this respect (CEN, PN, ISO,SPISE, ENTAM).

The participants agreed that the majority of IPM manuals ignore technical aspects. Sprayer ope-rators and advisors in crop protection emphasized the need for precise manuals with professional, con-firmed (reviewed) and reliable information on how to operate sprayers in particular conditions. In par-ticular, they should include the guidelines for drop-size determination and spray classes unified with PPP labels.

Some owners of sprayer testing units mentioned that the price of test should be determined by governmental decision and fixed similar to system used in periodic technical inspection of cars. Lea-ving unregulated prices for a standard and compulsory procedure leads to unfair competition and cor-ruption: cases of issuing certificates without a complete test were reported. Further standardisation of tests is needed – a relationship between scope and duration of sprayer tests should be established.

The diagnosticians opt for a 30-minutes procedure, including issuing the documents.

Diagnosticians and owners of workshops authorized for mandatory sprayers testing underlined the need to build some knowledge sharing platform connecting workshops, experts and advisors in plant protection. Therefore, the participants put forward that similar meetings and workshops should be re-peated periodically, with the presence of representatives of regulatory bodies. The meetings would fa-cilitate an open discussion and getting familiar with state-of-the-art in spraying systems testing equip-ment.

The participants agreed that – following the example of other EC countries and the requirements of the Directive 2009/128/EC – that the Polish Ministry of Agriculture and Rural Development should appoint an officer responsible for the mandatory system of sprayer testing.

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Air flow characteristics – proposed as mandatory requirement for airblast sprayers

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Introduction

The biological efficacy and environmental safety of pesticides application is worldwide more and more restricted. In European Community of 28 countries (EC28) since 2009 the Directive 2009/128/EC required governmental control of Plant Protection Products (PPP) use (Czaczyk 2010). According that since beginning of 2014 an Integrated Pest Management (IPM) was int-roduced as mandatory part of Integrated Plant Production (IPP). In EC28, according to this re-quirements, mandatory technical control of sprayers should be introduced till December 2016. The technical requirements concern new sprayers, and also sprayers in use.

Usually orchard and vineyard sprayers are equipped with air fan. It generate air flow for trans-portation of generated spray droplets of tank mix to the target. From different sources is known, that the air flow characteristics also at the same type (from the same manufacturer) of airblast sprayers is significant different (is not reproducible) (Triloff 2005, Triloff 2014).

The vertical liquid distribution from airblast sprayers strong depends on an air flow characte-ristics Hewitt 1993, Czaczyk 2012, Fritz et al. 2014). Because the air flow is invisible, it is di-fficult to evaluate its characteristics. According to new requirements for environmental safety of PPP application, the parameters influenced liquid distribution should be used to improve of the sprayer working quality. With aim to identify this problem, four different orchard sprayers with axial fun produced in Poland were tested. The non symmetric airflow characteristics were documented. It depends on the fan construction and also on rotational speed of propeller. According to the different air characteristics also liquid vertical distribution is influenced, and the changes of the target coverage and drift potential should be described by the manufacturer.

Methods

Special equipment for reproducible measurement of air flow characteristics were completed (fig. 1). An isosonic anemometer has continuos horizontal movement with constant speed. Also position (level) in vertical direction can be adjust continuously. But the scanned area is operated spatial – each 10 cm of height. The coordinates acquisition of isosonic sensor position is simultaneously conducted with the air flow results.

The operational software were created in own technical laboratory, with use of LabVIEW (Laboratory Virtual Instrument Engineering Workbench) system - design platform.

The air flow speed and direction are measured.

Fig. 1. View of air flow characteristic measurement unit based on isosonic anemometer.

Results

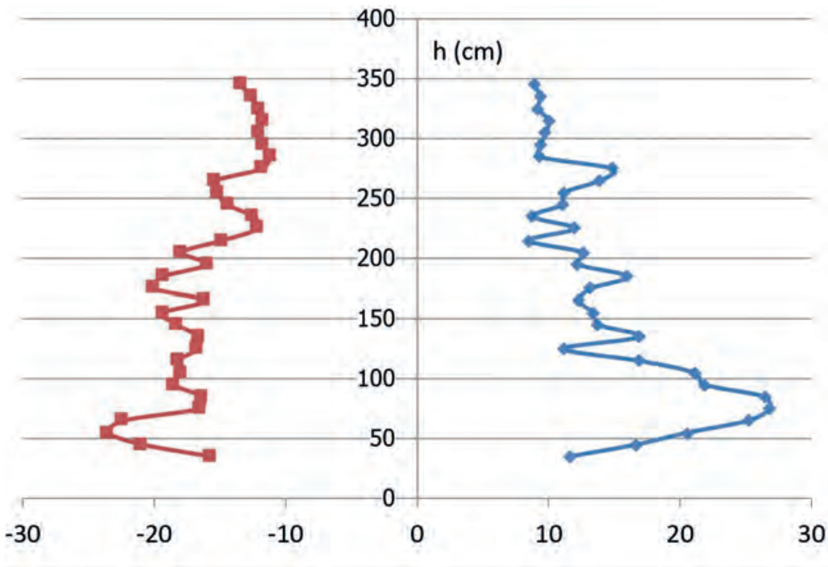

Fig. 2. Example of air flow velocity (m/s) of sprayer A.

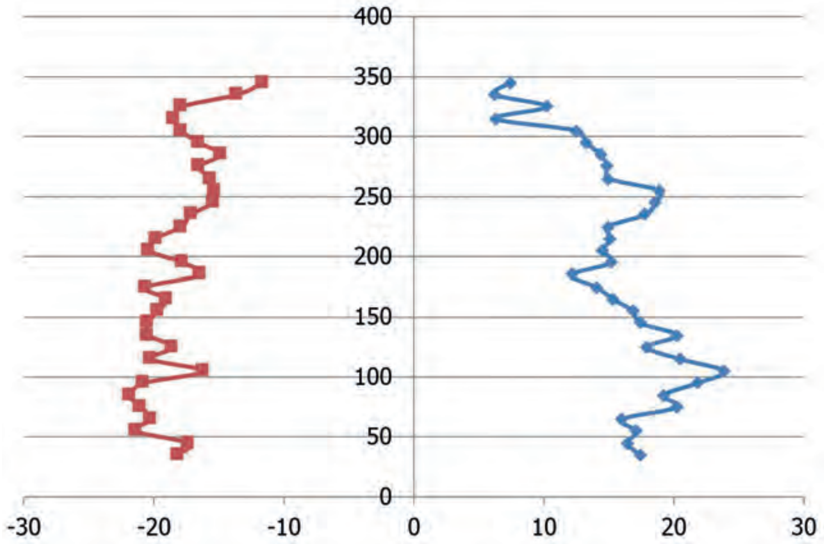

Fig. 3. Example of air flow velocity (m/s) of sprayer B.

Conclusions

The air flow from air blast orchard and vineyard sprayers influenced the drift potential signifi-cantly. The symmetry and characteristics of air flow usually is without any technical control during and after production of such sprayers.

The technical information about air fan adjustment for orchard and vineyard sprayers are very pure, and such technical information should be delivered more detailed and comfortable form for user.

The international standards (e.g. EN 13790-2, ISO 22369-1-3, ISO 5682-1-3) are useful for the working quality determination of sprayers. It improve the technological control and envi-ronmental safety of equipment supplied to the market. It influence in consequence also the technical level of sprayers used in practice.

The actual available standards for air blast sprayers should be improved with additional tech-nical regulations according to air fan characteristics and working safety.

The information about correct air flow adjustment should be include into the mandatory technical control of air blast sprayers, and also into the teaching material and training program for orchard and vineyard sprayers operators, users and advisors in crop protection.

Delivering of the air flow characteristics and the range of spraying range, should be required from sprayer manufacturer in technical information of each type of airblast sprayer.

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The comparison of the nozzle inspection methods in field crop sprayers: Nozzle flow vs. spray transverse distribution – methodology and some results

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Keywords: nozzle inspection, nozzle flow, transverse distribution, methodology

Introduction

Polish national procedure for the inspection of field crop sprayers in use allows two methods of evaluation of the nozzles working during the inspection of the field crop sprayers. Only three countries (Poland, Portugal and Sweden) use both methods (measurement of nozzle flow and transverse distribution) [Wehmann 2012]. Measuring only nozzle flow is carried out in four countries, and in the majority of countries only measurements of the transverse distribution of the spray are carried out, with the coefficient of variation CV% as a measure of accuracy.

The comparison of the nozzle inspection methods have not been carried out in a direct way. Therefore, it is not known which of these methods is more rigorous, and if both methods could achieve the same results. In order to compare the stringency and time-consuming of both inspection methods, the methodology of comparative tests have been elaborated.

Materials and methods

The elaborated methodology [Godyń 2013] describes how to compare and criteria for the evaluation of methods of inspection nozzles in field crop sprayers.

In all studies, three types of Lechler nozzles were used (utilized before for less than one hour) flat fan standard (LU 120-03) at 3 bar, flat fan air-injector (ID 120-03) and Twin flat spray air-injector compact nozzles (IDKT 120-03) at 4.5 bar. During the tests the electronic spray patternator SPRAYER TEST 1000 (PESSL Instruments, Austria) have been used. The trials on the groove patternator (STABEN - "mechanical") are planned to be done soon. The nozzle flow have been measured by SCHACHTNER (set of 20 scaled burets of nominal capacity 2000 ml and accuracy 20 ml) and ball flow-meter LURMARK.

For each of the method the time of removing and assembling nozzles or changing positions of nozzle bodies was measured and assumed as a common time for further calculations. For each of the evaluated method the time of each action was measured and the results of the study during the test were noted (CV%, mean nozzle flow rate, the number of the burets with 15% deviation from the mean and each nozzle flow rate). The gathered data allows the calculation of average time of the inspection of one nozzle depending on the type of the nozzle and the method used as well as binary and linear assessment of the test result.

The binary assessment expressed if the sprayer/nozzle inspection would be passed or not. The linear assessment expressed a percentage of fulfill the inspection criteria (eg. CV% or the maximum deviation from the nominal value of nozzle flow rate).

Example: For limit value of CV% or flow rate deviation = 10% (linear assessment = 100%):

if measured CV% / deviation = 5% - the binary assessment is 1 (passed), the linear assessment is 50%

if measured CV% / deviation = 15% – the binary assessment is 0 (not passed / failed), linear assessment is 150%.

The comparison of the means for the linear assessments obtained for each nozzle type or inspection method answers whether the compared methods are equally "rigorous".

The repeatability of measurements was evaluated using the coefficient of variation for repetitions.

Results

The measurements of the transverse distribution uniformity were done by means of the electronic patternator SPRAYER TEST 1000 for the field crop sprayer Krukowiak with the 12 m long boom. The most uneven transverse distribution of the spray was measured for standard nozzles LU-120-03 (mean binary assessment = 0, all repetition failed; mean linear assessment = 104.55%) and the most equal for the air-injector ID-120-03 nozzles (binary = 1; linear = 64.08%). The CV% value for the first repetition of the IDKT nozzles (10.74%) clearly differed from three others (< 8.8%), therefore binary assessment achieved 0.75 (one failed) and linear one = 92.00%. A possible reason for a such difference was elimination of the spraying on to the spray line by one of the nozzles, noticed after the first measurement.

The average time of a single measurement (one position of a scanner) for standard nozzles was 36.5 seconds in comparison to 32.6 seconds for the air-injector nozzles. The mean test time of a single nozzle depended on the flow rate of the nozzle and the flow was pressure dependent. In this study, the 3.0 bar pressure was used for the standard and 4.5 bar for the air-injector nozzles (acc. to the Regulation of Ministry of Agriculture concerning sprayers inspection).

Average time of the assembling one nozzle was 29.06, 12.53 for disassembling and 1.53 seconds for rotating a nozzle body. The results of measurements will be used to simulate full inspection time for the method with all nozzles removed from the boom and/or for booms longer than 12 m or equipped with more than one set of the nozzles.

Conclusions

When the study will be finished it will be possible to answer which inspection method is more time-consuming or more restrictive. Preliminary analysis of the data obtained for a single measurement method shows the significance of a nozzle type in the final assessment of the evaluated method. The other data show differences in accuracy, time consuming and costs of different methods.

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Electrostatic Method to Measure the Size of the Sprayed Droplets

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Abstract

In the paper is presented the new method the measurement of the main parameters the atomised stream of liquid. This method base on the measurement of the electric charge carried by water drops charged by high voltage. The electrostatic sensor to measure of the droplets size, is associated with precision mechanic system scanning the sprayed surface. The amplified and conditioned signals from electrostatic sensor are send to the computer system equipped in virtual instrument to analyse the size and spatial distribution of droplets. The virtual instrument control also the scanning system.

***Keywords*:** droplets size, electrostatic, measurement systems.

Introduction

The spray technique is largely used in the agriculture, food technology and industry. To obtain the good results in spraying of the liquid, the droplets created by the sprayer have to possess exactly determined properties. The most important properties of the spraying droplets are: the size of droplets, the homogeneity of size and uniformity of the covering surface by the drops. Actually exist a few method to measure the droplets size there are the optic and photographic methods to measure the traces of the droplets made on special paper or to photograph the droplets during their movement from sprayer to the target. If it is necessary to obtain pinpoint measurement of this parameter the best manner is so called Doppler-Laser method. But the weakness the most currently used methods is their high cost and big dimensions like the Doppler Laser method, or complicated and long procedure to measure and pick-up the data in the optics and photographic methods. The electrostatics method to measure the droplets size, associated with the computer controlled scanning system, make possible to measure and evaluate the main properties of the spraying system. This method give the possibilities to obtain all information about sprayed stream, instantly on the computer screen in the intuitive graphical form. The measurement system permit to evaluate and regulate the sprayers precisely and quickly.

In the classical electrostatic method the measure system is composed the two main modules: the first is the loader drops of electric charge. The second module is a measuring unit measures the size of the lifted electric charge and specifying on this basis the size of atomized droplets of liquid. This movement of the charged drop can be investigating like a convection current between charging electrode and receiving electrode, which is connected with measurement system .

Laboratory stand

To exam the dependence presented above the laboratory stand has been constructed by the author in, University of Life Sciences in Lublin Poland (fig.1). This stand makes possible to change the range of charging voltage, the size and distance of passage the drops.

This work-stand simulate the condition of drop movement and let to determinate influence different factors of the spraying on the value of convection current. To obtain repeated results was applied a drop distributor which assured emission drops with various size . The distance between the drop distributor and the receiving electrode was changed from 2 cm to 200 cm.

The measurement system is composed with input circuits, instrumentation amplifier, digital oscilloscope, analog to digital converter (AD converter) and computer. The electrostatic sensor and measurement unit give the possibility to measure the convection current. On this base we can calculate the electric charge carried by drops. All these results were recorded on PC.

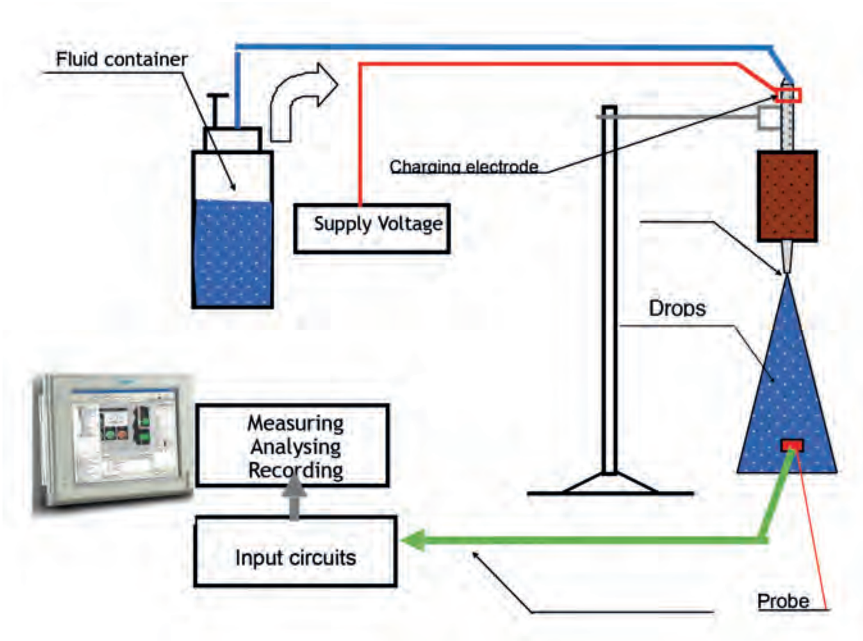

Fig. 1. Laboratory stand.

On the fig.2. are presented the waveforms of the signals coming from receiving electrode.

During the experiment the charge of the water drop was measured as the function of the distance passed by drop. The range of the distance passed by drop was from 2 cm to 200 cm. The experiment for each test was repeated 10 times. During this test was also observed influence of charging voltage on the results.

Fig. 2 shows the waveforms of the voltages on the receiving electrode during the discharging the water drops for selected highest.

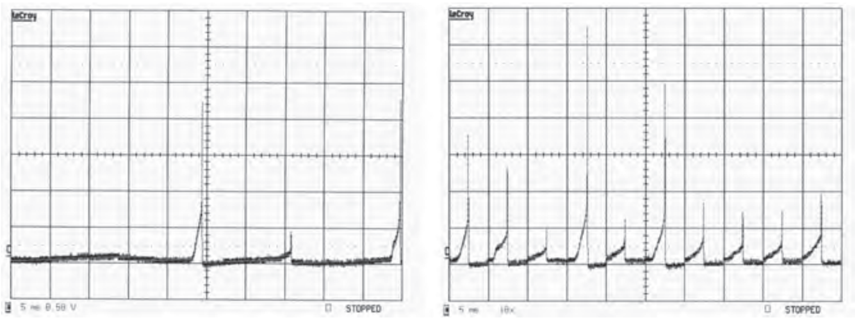

Fig. 2. Waveforms of the signals received from measurement system a) single signal b) series of signals.

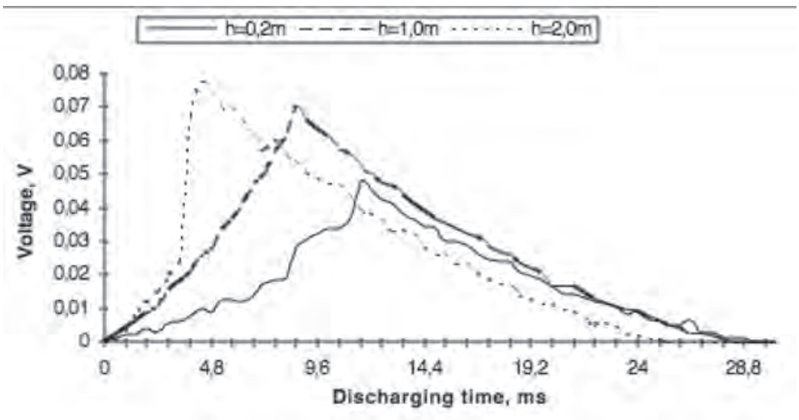

Fig. 3. Waveforms of discharging voltage.

Because the theoretical and experimental investigation confirm that electric charge is proportional to the mass of drop it was possible to construct small electrostatic drops mass detector, which can determine the dimension each individual droplet. The research proved also that electric charge carried by drops doesn't depend on distance passed by charged drops if the distances are located in the range between 10 cm to 200 cm.

Results of the research

A special virtual instrument was constructed to control the system of the scanning the analyzed area of spraying and to receive and analyze data from sensor. The electrostatic sensor to measure of the droplets size, was associated with precision mechanic system scanning the sprayed surface. The amplified and conditioned signals from electrostatic sensor were send to the computer system equipped in virtual instrument to analyze the size and spatial distribution of droplets. The instrument can define the parameters of scanning to obtain desirable "density" the points of measure as it is shown on fig.4.

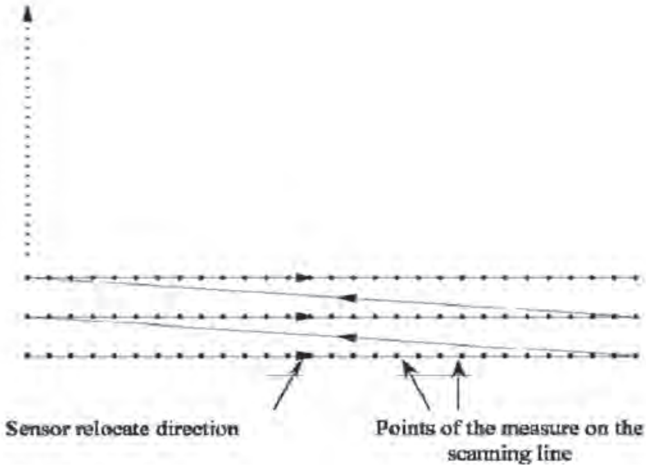

Fig. 4. Schema the relocate of the electrostatic sensor on the sprayed area.

The data are transmitted to the computer and analyzed by the program allocate in the virtual instrument. The results of the analyze are visible immediately just on the computer's screen. Each point of the measure on the scanned sprayed area is represented by group of pixel on the screen.

Conclusion

The investigation proved that the electrostatic method to measure the mass of drops, associated with precision scanning system, controlled by virtual instrument can possible to measure the main properties of spraying system. This method is quickly and give the instantaneous results of the measure and analyze of the distribution the droplets on the investigated area of spraying. Low cost, small dimensions of the instrument and the possibility to be mounted directly on the spryer working on the field, give the opportunity to this method to be applied for periodically control the quality of spraying. The instrument permit also to evaluate the drift of the spray created by the wind.

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User concerns about sprayer inspections in the Comunidad Valenciana (Spain). Importance of adequate communication for the higher involvement of stakeholders.

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Directive 2009/128/EC for a Sustainable Use of Pesticides was transposed to the Spanish legislation in 2011 through the Royal Decree 1702/2011, which established the national core legislation for the inspection of sprayers. According to the Spanish regulatory system, Regions (Comunidades Autónomas) are in charge of the technical implementation of the inspections. The government of the Comunidad Valenciana published the executive regulations for this Region on July 29th 2014. Furthermore, as of March 2013, four training courses for inspectors have been organised jointly by the Conselleria de Agricultura (Regional Ministry of Agriculture) and the Universitat Politècnica de València. Special care has been taken to harmonise inspection procedures with the rest of the Spanish Regions, as well as Europe.

The Centro de Agroingeniería of IVIA belongs to the Conselleria de Agricultura and is in continuous contact with national sprayer manufacturers, farmers and end-users. Moreover, it organises courses for professionals and is involved in research projects and tests related to field sprayer machinery (Fig. 1).

Fig. 1. Training activities conducted by the Centro de Agroingeniería.

From the participants in these activities, the Centro de Agroingeniería has collected a series of feelings related to the condition of the sprayers and the farmers' perceptions regarding the compulsory sprayer inspection, not only in the Comunitat Valenciana, but also in other regions of Spain.

As positive feelings, it could be said that there is an increasing sensitivity of farmers towards food and environmental safety. A growing number of farmers are becoming increasingly aware that pesticide treatments are necessary but generate risks to people and the environment, as well as being a potential threat to themselves. On the other hand, the emergence of new technologies is promoting the renewal of the equipment currently in use, which improves the condition of the sprayers, although this change is still only occurring in a minority of cases. These positive changes may be largely due to the generational change and the professionalisation that is taking place in the agricultural sector.

Nevertheless, positive feelings are less common, since during these training activities end-users raised concerns above all related to the use of the sprayers. Firstly, one of the main problems observed is that there is a lack of knowledge of the legislation concerning not only the inspection of the sprayers, but also their use and ownership. Sometimes, farmers do not know anything at all about these issues. When they are aware, some of the first concerns are related to the official registration of sprayers (Official Register of Agricultural Machinery, ROMA), which is compulsory in Spain. Farmers have the responsibility to arrange this administrative process in their local government offices, but many of them are unaware of the procedure, or think that they would have difficulties to register their sprayers because of their age and lack of documentation, which has often been lost or damaged. Nowadays, this is no longer a problem, since the procedure has been changed in order to make registration possible in such cases, but the fact is that this information has not reached the users.

Other concerns are related to the inspection procedure. These concerns arose because there are certain devices that are part of sprayers currently in use which are inspected that usually show problems. These could be divided into two groups. On the one hand, there are problems that could be cheap and easy to solve. Among these, the most common are related to the absence of or ineffective PTO shields (Fig. 2), inadequate or useless tank level indicators (Fig. 3), the impossibility of emptying the tank without losses (Fig. 4), inadequate manometers (Fig. 5), ineffective or nonexistent isolation of the aspiration filter, and bad nozzle condition (impossible identification and/or off-range flow) (Fig. 6).

Fig. 2. Absence of PTO shields.

Fig. 3. Useless tank level indicator.

Fig. 4. Impossibility of emptying the tank without losses.

Fig. 5. Inadequate manometer (Excessive scale and insufficient resolution).

Fig. 6. Bad nozzle condition.

On the other hand, there is another group of common problems that would require technical assistance and may be far more expensive to solve. Among these, the most common could be those related with the pumps, which usually show irregular flow (pulsations) and/or losses (Fig. 7), the existence of high-pressure conduits in the tractor cabin (Fig. 8), inexistent or ineffective anti-drip devices (Fig. 9), or high pressure drops between the high pressure pump and nozzles.

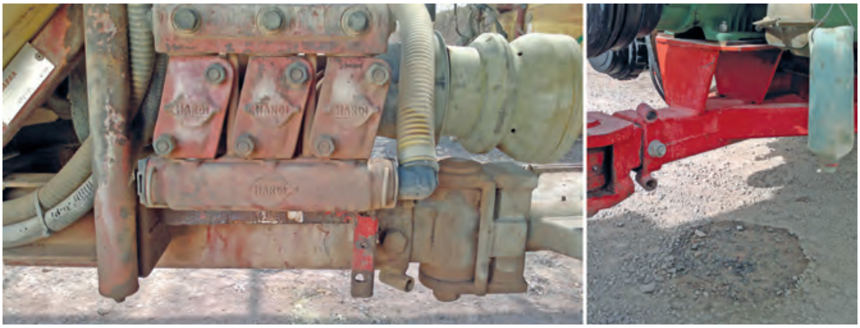

Fig. 7. Losses from the pump.

Fig. 8. High-pressure conduits in the tractor cabin.

Fig. 9. Ineffective anti-drip devices.

All these concerns make the farmers believe that the inspection is just a waste of money, and that the new legislation, together with the low incomes they have, may force them to leave the agricultural activity. Since many of them see the inspection as a threat, not as a social demand or an environmental and safety need, an important pedagogical effort is required to disseminate the advantages of the inspections to farmers. End-users need to be convinced about the economic advantages of the correct use of sprayers and the increase in safety and efficient use of resources that inspections may provide. Moreover, they should be trained in the regulation of their sprayers and the advances they would achieve through doing so, since all the problems mentioned above would be minimised.

Furthermore, communication between all the stakeholders, from lawmakers to farmers, and the commitment of all them are essential to successfully reach not only Directive 2009/128/EC requirements, but also a real sustainable use of pesticides.

Implementation status of mandatory inspection of sprayers in Romania

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Summary

To harmonize the Romanian legislation on plant protection to the European legislation the Directive 128/2009 has been transposed into national legislation by Government Emergency Ordinance 34/2012 on establishing the institutional framework for action to the sustainable use of pesticides in Romania.

National Action Plan approved by Decision 683/2013, on reducing the risks associated with the use of plant protection products is the strategic document regarding the continuous improvement of the use of plant protection products and contains quantitative targets, measures and timetables to reduce risks and the effects of using plant protection products on the environment and human health.

Introduction

The National Action Plan, developed on the basis of Article 4 of GEO 34/2012, is the basic document on continuous improvement in the use of plant protection products, and aims to: establish the institutional framework to achieve sustainable use of pesticides, reducing dependence on pesticide use, reduce the risk and effects associated with pesticide use and promotes integrated Pest Management.

Through NAP are developed and implemented the integrated pest management system, are encouraged the introduction of plant protection products containing active substances with low degree of hazard, the alternative techniques to reduce the use of plant protection products and optimization of control methods.

The current situation in Romania

The National Phytosanitary Agency trough the County Phytosanitary Units was designated, by Order 1463/26.09.2014, as *Inspection Body* of the equipment for applying plant protection products for professional use. The Inspection Body has in its structure *Testing Centers* founded and organized at the compartment level into County Phytosanitary Units

Trough the responsibilities of the Inspection Body - National Phytosanitary Agency- are the following:

- Initiation and implementation of laws, rules, procedures and instructions that governing the inspection of pesticide application equipment in Romania;
- Coordinate the organization and implementation of the system of inspection of equipment for pesticide application at national and local level;
- Providing, together with the General Food Industry Direction - Department of consulting, extension and training, the staff training from test centers and professional users;

- Ensuring development of the Official Register of machinery and equipment for pesticides application - their registration being prerequisite for inspection;
- Develop the control and monitoring plan for implementing optimal inspection system;
- Ensure developing of a database for recording specific information on implementation of inspection for plant protection equipment;
- Ensure developing of a website dedicated to inspection system of the equipment on MARD website;
- Organizing information and awareness campaigns about the requirements and benefits of pesticide application equipment inspection.

The *Testing Center* will be coordinated by an inspector, and will have the following responsibilities:

- Make assessment and certification of application equipment under a service contract between the equipment owner and the inspection body;
- Prepare the annual inspection report for the equipment tested;
- Register the information regarding the test results in a registry prepared at each test center;
- Issuing the certificate of inspection and an adhesive bead that will be applied on the equipment, and transmits them to the equipment owner;
- Managing the database on inspections to monitors the testing system at the local level;
- Establish guidelines for maintenance and use of application equipment;
- Ensure the confidentiality of information provided by the owners of equipment.

Conclusions

- The transposition of EU legislation at national level is completed;
- The responsible body for inspection of pesticide application equipment was designate;
- Were established the responsibilities of the Inspection Body (Order 1463. / 26.09.2014);
- There is no working testing center, yet.

Present situation of the inspection of sprayers in use in Spain

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1. Introduction

The first voluntary inspections in Spain were carried out in the eighties for the sprayers used in integrated pest management schemes and later on under the Eurepgap or other certification programmes. These inspections were usually made directly or managed by public institutions.

At present, the total number of sprayers to be inspected all over the country is not known. From 2009 on, the official registration of all application equipment, both new and in use, is compulsory. For sprayers in use a simplified method has been agreed, since the technical documents of the machine are usually not available. The Ministry of Agriculture is in charge of this official list, which is managed by the regional authorities. So far, around 170000 sprayers are included, but it is believed that the total number must be much higher.

Besides of giving information about the numbers, this official registration allows to know the geographical distribution of the sprayers (Fig. 1), and this is an important tool for the management of the inspection programme. As an example, Fig. 1 shows the distribution of sprayers in Catalunya, in the North East of Spain. When implementing the inspection scheme, it has to be assured that all the sprayers can be inspected, close to the place where they are located.

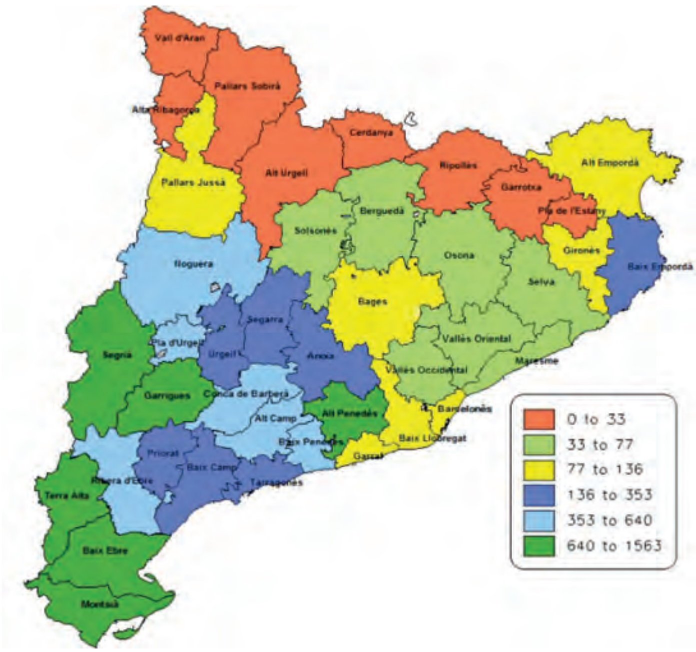

Fig. 1. Geographical distribution of the sprayers in use in Catalunya (October 2014).

2. The European Directive for the sustainable use of pesticides and the Spanish law

As it is established in the 2009/128/CE directive, at the end of 2012 the Spanish National Action Plan, was sent to the European Union. There, it is said that the inspections of sprayers in use will be made according to the Spanish Act "RD1702/2011", which is the way the European directive has been adopted in the Spanish legislation.

Although the Spanish Plant Protection Law from 2002 already included the inspection of agricultural sprayers, the date of the publication of the RD1702/2011 can be considered as the actual starting date for the compulsory inspection of sprayers in Spain. In fact, it was agreed by the Ministry, that the inspection programme would not be implement till the publication of the European Directive.

The expertise that was acquired from the former voluntary inspections and from other European countries, which have been carrying out compulsory inspections for many years, has been very useful for the implementation of the current compulsory inspection scheme, although they have to be adapted so that the inspection programme matches the local needs.

Sprayer operators that are used to voluntary inspections are more willing to participate in a compulsory programme, mainly if the requirements are similar. However other constraints can appear, like an increase in the price of the inspections, since voluntary inspections usually were free or only a low fee had to be paid.

The National Action Plan establishes which sprayer types are going to be included in the inspection programmes, and which are going to be excluded.

Application equipment included in the inspection programme:

Mobile application equipment for agricultural and other use

Horizontal boom sprayers

Sprayers for bush and tree crops

Pneumatic sprayers

Spinning disc sprayers

Dusters

Aerial application equipment

Application equipment for greenhouses and other indoor facilities

Application equipment excluded from the inspection programme:

knapsack sprayers

human-trailed trolley sprayers of a tank capacity of less than 100 l.

train-mounted sprayers

After 2020, all sprayers have to be inspected every 3 years. In the period between now and 2020, sprayer inspections have to be carried out every 5 years, except for contractors, who already have to carry out the inspections of their sprayers every 3 years. Finally, as it is stated in the directive, new sprayers have to be inspected the first time within the 5 years period after being sold.

3. Inspection workshops

In relation to the sprayer workshops (known with the ITEAF acronym), their staff will be composed of a director and an inspector, which have to pass a training course, besides of having the adequate background academic formation or professional expertise. In general, the sprayer manufacturers or dealers are not allowed to set up an ITEAF. The ITEAF is not allowed to repair the sprayer failures and the adjustment and calibration of the sprayers is not made either as a part of the sprayer inspection. The inspection fees are freely decided by every inspection workshop, according to the real costs, so they can change according to aspects like the kind of sprayer or the total number of sprayers to be inspected in a same place. There is no a tax that has to be paid for every inspection, as it is in other countries.

Inspections carried out in other countries by certified workshops will be recognized. Workshops authorized in other countries will also be acknowledged to carry out inspections in Spain. So far, there has not been any such application, so questions as the different validity periods in different countries have not yet arisen.

There is a software for the inspection of sprayers in use, PRITEAF (Fig. 2), which is provided to the inspection workshops by the Spanish Ministry. A data base with the results of the inspection will be available from the web page of the Ministry. It will give information about the defects encountered if the sprayer fails the inspection. No information about the technical characteristics of the sprayers is given in this data base, beyond the type and location of the sprayer. The use of the PRITEAF software by the inspection workshop will make easier the making of the data base.

Fig. 2. Handbook of the PRITEAF software for the inspection of sprayers in use.

4. Organization of the inspections

Under the coordination of the Spanish Ministry, the regional governments are responsible for the organization of the inspections. At present, the main concern of the regional regulatory bodies is to assure that by the end of 2016, as established in the European Directive, all sprayers will be inspected at least once.

During 2013, 8 training courses for the workshop staff were carried out by different Universities all over Spain and 6 more are scheduled for 2014. At the same time, the first inspection workshops after the adoption of the Directive have been authorized (16 all over Spain, when writing this paper) and the first inspections have already been carried out in some regions. However, the number of sprayers inspected at the moment of writing this paper (end of 2014) is still very low in relation to the total amount of them.

The main constraints, which appear while implementing the inspection programme are the financial problems in some farms, which make difficult the payment not only of the inspection fees but also of the cost of the repairs that have to be made, so that the sprayer can pass the inspection. Besides, sometimes the advantages of the inspection are not well understood, and they are seen just as a new tax burden. The most important positive aspects to be considered by farmers are the pesticide savings, which derive from the increase of the application efficiency of the sprayers, and the safety of the operator.

5. Methodology for the inspections

Sprayer inspections are carried out according to the methodology established in the EN 13790:2003 standard. Now, this standard is updated with the new ISO EN 16122 series, so that, following a mandate of the European Comission, it will be harmonised with the 128/2009/CE Directive.

There is an inspection handbook, which is available from the webpage of the Ministry, that provides information on practical issues that can arise during the inspection. So it can be considered as a guideline that should be followed by the inpsectors.

The contents of the handbook is based on the actual sprayer inspection standard. For every inspection item, the defects that make the inspection to fail are described by means of a detailed explanation and also with photographs. Some procedures for the inspection of application equipment like dusters of handheld guns, for which a standard has not been developed yet, are also included in the handbook.

6. Reference Laboratory

The designation of *Centre de Mecanització Agrària* as the National Reference Laboratory aims for a technical harmonization of the sprayer inspections carried all over Spain. Harmonization is a key issue, when there are more than 17 regional authorities responsible for the different inspection programmes.

The reference laboratory is in charge of the

- Technical harmonization of the sprayer inspections
- Methodology for the inspection, based on the new EN-ISO 16122 standards
- Guidelines for quality control of the inspection workshops
- Assessment of the methodology for sprayer inspections

So, the responsibilities of the reference lab are similar to organizations in other countries, like GIP pulves in France, JKI in Germany or SKL in Holland. They all have to give an answer to both technical and administrative questions related to the development of the inspection programme. This task is very important during the present period, when compulsory inspections have been started up and the programme has to be implemented.

The reference laboratory is also in charge of testing the different inspection methodologies and checking the inspection equipment. In this aspect, several tests for the assessment of the nozzle flow rate measuring equipment and the different methodologies for the measurement of the spray distribution in field crop sprayers (Fig. 3) are being carried out. The goal is to assess the inspection workshops on the best methodology for the inspections.

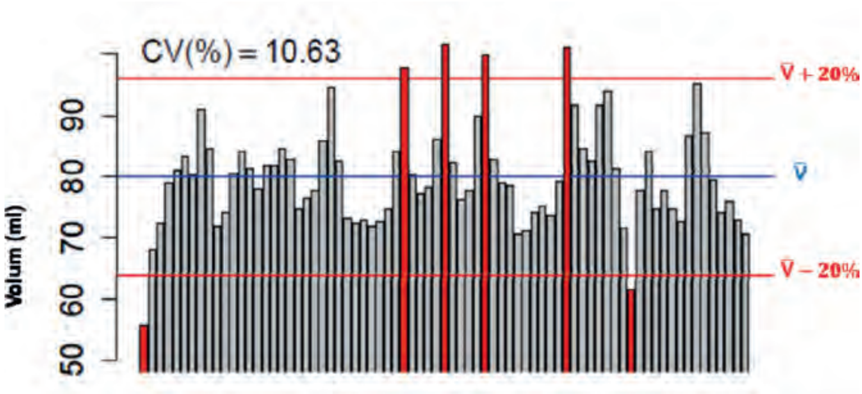

Fig. 3. Measurement of the spray distribution in a boom sprayer for the assessment of the spray inspection methodology.

Moreover, bearing in mind the publication of the new standards for the inspection of sprayers in use (EN-ISO 16122), it is planned to update the existing inspection handbook, in those aspects that will be new or will be changed in relation to the old standards.

It is also the responsibility of the reference laboratory to prepare a quality assurance scheme for the inspection workshops and also assessing them in the calibration procedures of the measuring equipment used in the inspections. In this way, it won't be compulsory for the inspection workshops to be certified by an official body, according to standards like ISO 17020, a procedure that small organizations, like most of the ITEAFs, cannot afford.

Practical experience in running Field Sprayers Inspection Station, and measuring tools design and their implementation

J. Zubek

Owner and Inspector for Field Sprayers Inspection Station
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The aim of the research was to find alternative, faster, cheaper and more accurate methods of measuring the flow of liquid from field sprayers nozzles with free flow, and the development of devices for doing so. I believe that the prevalence of use our tools will significantly speed up the inspection process, while increasing its reliability and precision. Developed devices MicroFLOW (Fig. 1) and SprayerTEST (Fig. 2) use well known principle of measuring the intensity of the free flow of liquid from any source actually. They use also best technical solutions presented by other companies, but our invaluable advantage is the possibility of any technical adaptation and modification of software. Microflow and Sprayer Test has been developed after several months of testing, training and research.

Fig. 1. MicroFLOW in use.

Fig. 2. SprayerTEST in use.

Work on the device is still going on - in the adaptation displays, flow meters, algorithms. The target will be designed several versions of the device, for simultaneous measurement of a few or several nozzles at the same time. Any of your opinion will be my determinant for further design work and programming, which allow for the improvement of technical parameters and performance presented devices, and will stimulate to the completion of the inspection device for orchard spraying. Also 2.4 GHz communication become available.

Data collected during our activity (fig. 3 and 4) – can show what are the main technical problems, and inquiry were result of most problems for farmers why farmers are not well prepared:

lack of information, no information published, or not appropriate way

reluctance despite of sanctions – sanctions are to small;

to long inspection intervals – everything can be done with sprayer during that time;

inspector is a weak link – just only pay the inspector;

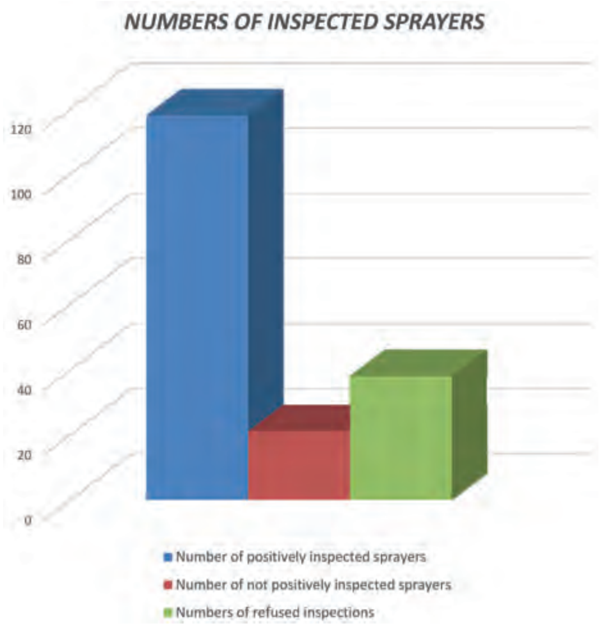

Fig. 3. Number of inspected sprayers.

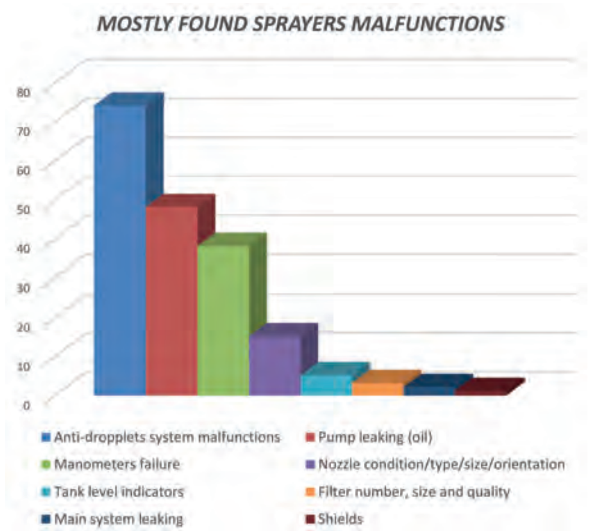

Fig. 4. Mostly found sprayers malfunctions.

Excursion for visiting inspection centers

The excursion took place on the 16 October 2014. With this it should be achieved a better understanding for the work organized by the GIP Pulvés in cooperation with the inspection places of the region. Over that some research and consulting centers were visited regarding the investigations in the field of pesticide application equipment.

Programme of the 16 October 2014

Montpellier

IRSTEA

Fig. 1. Visit of the testing facilities.

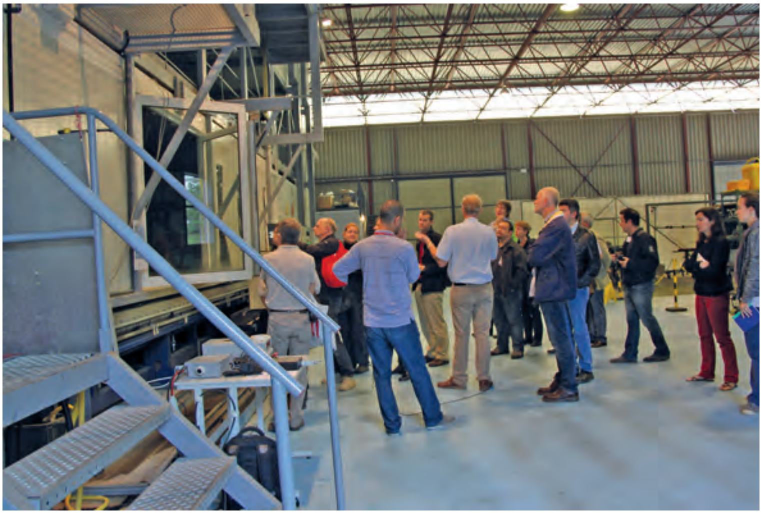

Fig. 2. Demonstration of wind tunnel experiments.

Fig. 3. Demonstration of sprayer inspection and testimony of an inspector.

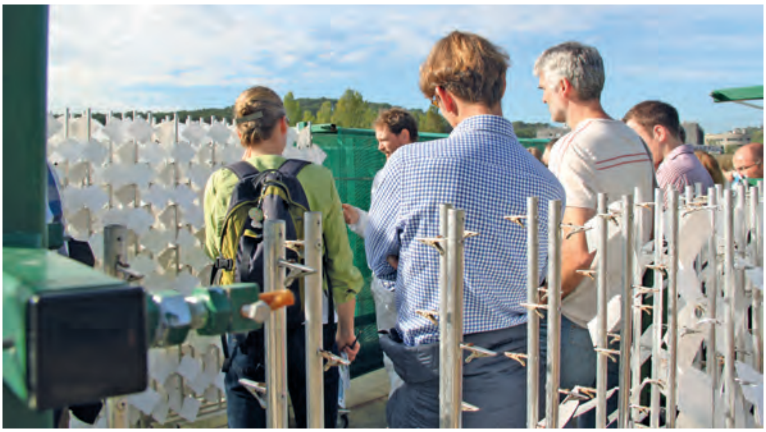

Fig. 4. Demonstration of Ecospray Viti test bench.

Villeneuve les Maguelonne

Domaine du Chapitre

Fig. 5. Visit of the winery.

Marsillargues

Experimental station for horticulture (CEHM)

Fig. 6. Demonstration of vertical patternator AAMS-Salvarani.

Fig. 7. Illustration on different air-assisted sprayers.

Fig. 8. Demonstration of mosquito control equipment from EID Méditerrannée.

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Fifth European Workshop on Standardised Procedure for the Inspection of Sprayers in Europe – SPISE 5-

Die Richtlinie 2009/128/EC verpflichtet die Mitgliedstaaten bis spätestens 14. Dezember 2016 für Pflanzenschutzgeräte eine turnusmäßige technische Überprüfung einzuführen.

Die Mitgliedsstaaten sind für die praktische Umsetzung der europäischen Regelungen verantwortlich. Um die Details möglichst einheitlich festzulegen, ist ein umfangreicher Erfahrungsaustausch von großer Wichtigkeit. Die SPISE workshops bieten hierzu eine ideale Plattform. Vom 15. bis 17. Oktober 2014 fand der fünfte SPISE-Workshop in Montpellier (Frankreich) statt. Der Workshop wurde wieder organisiert von der SPISE Working Group (SWG), der Vertreter aus Belgien, Frankreich, Italien, Niederlande und Deutschland (Chairman: Prof. P. Balsari) angehören. Die Teilnehmer kamen aus Prüfungs- oder Forschungsinstituten, Verwaltungen oder Firmen und brachten die nötige technische Expertise mit. Mit einer Beteiligung von ca. 100 Experten aus 23 Europäischen Ländern und 2 nicht-europäischen Ländern (Brasilien und Kanada) ist dieser SPISE5-Workshop wiederum auf große Resonanz gestoßen.

Im vorliegenden Tagungsband sind alle Vorträge, Poster und weiteren Unterlagen des aktuellen Workshops zusammengestellt.

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The directive 2009/128/EC obliged the Member States to ensure that all pesticide application equipment in professional use shall be subject to inspections at regular intervals till 14. December 2016.

The Member States are responsible for the practical realization of the European regulations. To define the details as uniform as possible an extensive exchange of experience is essential. For this purpose the SPISE-workshops offer an excellent platform. From 15 to 17 October 2014 the fifth SPISE-Workshop took place at Montpellier (France). The Workshop was organised by the SPISE Working Group (SWG), to which representatives from Belgium, France, Italy, the Netherlands and Germany belong (Chairman: Prof. P. Balsari). The participants came from inspection and research institutes, administration and private companies and brought with them the necessary technical expertise. The SPISE5-Workshop met with a very positive response, demonstrated by the 100 experts who took part from 23 European countries and from 2 Extra-European Countries (Brazil and Canada).

The present proceedings contain all presentations, posters and further documents of the latest workshop.

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