Sixth European Workshop on Standardised Procedure for the Inspection of Sprayers in Europe

SPISE 6

Barcelona, Spain, September 13 – 15, 2016
Paolo Balsari, Emilio Gil, Hans-Joachim Wehmann [ed.]

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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 seven times. They presented the state of work and of the preparation of the so-called SPISE advices.
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Summary 6th European Workshop on Plant Protection Equipment Inspections - SPISE 6 Workshop

The SPISE 6 Workshop took place at Barcelona, Spain, on 13 to 15 September 2016. About 100 participants from 27 European Countries and from Extra-European Countries (China and Iraq) took part. The locally organization was under the responsibility of the Escola Superior d’Agricultura de Barcelona, Universitat Politècnica de Catalunya (UPC), Spain. The Workshop site was the Campus del Baix Llobregat, Castelldefels. The Workshop was held by the SPISE Working Group (SWG), to which representatives from Belgium, Germany, France, Italy and the Netherlands belong, in collaboration with the Escola Superior d’Agricultura de Barcelona, the Ministry of Agriculture and Fisheries, Food and Environmental Affairs of Spain and the Generalitat of Catalonia.

The 6th edition of SPISE workshop covered important aspects: The recently published harmonized EN ISO 16122 for inspection of sprayers in use, and the deadline according the EU Directive 2009/128/EC – November 26th 2016 – for the accomplishment of the official mandate. It was an interesting opportunity to evaluate the present situation on MS and to understand the difficulties encountered and the necessary actions needed to solve them. It was also possible for the participants to evaluate and discuss about the recently entered in force harmonized standard on the inspections of sprayers used in greenhouse (ISO EN 16122-4).

The Workshop began with a round table session, where a representative from the Commission (P. Kiss, EC, IR) made a presentation on “Current implementation of inspections of pesticide application equipment in the EU following SUD requirements”. Further speakers reported on “Status Quo of inspection in EU: The results of a SPISE enquiry” (H. Wehmann, JKI, DE) “The PAE inspection in Spain and Catalonia” (A. Goutan, Generalitat of Catalonia, ES), “The experience of the mandatory sprayers inspection in Greece” (T. Balafoutis, University of Athens, GR), “The point of view of a farmer” (C. González, COPACOGECA, ES) and “The advantage of sprayer inspection from the dealer’s point of view” (E. Hogervorst, CLIMMAR, NL).

The attendance and the involvement and interest of Ms. Kiss as new representative from DG SANTE are seen as a sign of recognition for the work done by SPISE.

The content of the specific following 7 sessions was prepared by the Technical Working Groups (TWGs) which were installed at the SPISE 4 workshop at Lana in 2014. In detail the following sessions were offered:

- **Session 1:** Inspection of brand new sprayers (TWG 1)
  Chairman: E. Gil, C. Schulze-Stentrop

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

- **Session 3:** Sprayer inspection harmonised test methods (TWG 3)
  Chairman: J.-P. Douzals, V. Polvêche

- **Session 4:** Certification” of the Workshop activity (quality assurance) included the certification of devices/ instruments used for the inspections (TWG 4)
  Chairman: 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: Present experiences and problems in inspections activities (TWG 6)
  Chairmen: E. Gil, H. Kramer, J. Kole

- Session 7: SPISE TWG activities and SPISE advice on PAE not yet considered by harmonised Standards (TWG 7)
  Chairmen: J. Wegener, P. Balsari

More than 40 presentations from the participants plus 7 posters showed the ongoing activities in the Member States and the current situation regarding the introduction of plant protection equipment mandatory inspections in the MS.

The attending countries were able to report on the present activities and was underlined the installation of the inspection systems in all MS.

During the discussions assigned to each session it was determined repeatedly that due to different reasons most of MS cannot guarantee to complete the first inspection of all PAE in professional use by the deadline of 26th of November 2016.

As also mentioned in the frame of the 5th SPISE Workshop there is a need for specific advices to fulfil the requirements of the Directive 2009/128/EC (Sustainable Use Directive) that should be implemented and applied. In the following it was decided to prepare “SPISE Advices” to each of the issues considered by the SPISE TWGs. In the meantime, the first Advices are published and free downloadable from the SPISE Website.

The second day was dedicated to practical demonstration of the sprayers’ inspections activities with particular effort to the inspections of sprayers used in greenhouse.

The first demonstration was held at the Finca Agustí farm, where are cultivated outdoor vegetables as celery and tomatoes. The participants were divided in three groups and were invited to follow/conduct inspections on a field crop sprayer, an orchard sprayer and also an orchard sprayer equipped with a spray gun. For this purpose, the colleagues of UPC and Agricultural Mechanization Centre (CMA) developed a special test report which was explained and filled in step by step by appointed tutors.

The next demonstration was at the company of Agromillora Iberia, which is an international nursery dedicated to the production of fruit and olives trees. The focus here was laying on the inspection of sprayers for greenhouse application following the new harmonized standard (ISO EN 16122). Also here a specific test report prepared by UPC and CMA was the basis for the group work. Furthermore the groups participated in a presentation of a special fogger equipment and followed a guided tour through the greenhouses of the company. At the end of the demonstration a general discussion on this new standardized inspection methodology was held and operative problems underlined.

Information portal: http://spise.jki.bund.de
Opening Ceremony / Round table

Status Quo of inspection in EU: the results of SPISE enquiry

H.-J. Wehmann

1Julius Kühn-Institut, Institute for Application Techniques in Plant Protection, Messeweg 11/12, 38104 Braunschweig, GERMANY

Summary
With a view to the SPISE 6 workshop during the spring time of the year 2016 once again a survey in the European Member States and other countries in Europe was carried out. The aim of this survey was to compile information concerning the actual situation of the inspection of pesticide application equipment PAE in use and this time especially the occurrence of problems connected to the implementation of an inspection system. The responsible colleagues of all involved countries got a short questionnaire where they updated the filled data and gave new information.

Introduction
On the occasion of the previous SPISE workshops in the year 2004, 2007, 2009 and 2012 similar surveys were carried out.

With this actual survey the colleagues were asked for updating the data regarding the inspection of field and air-assisted sprayers, fixed and semi-mobile sprayers, foggers, PAE used for seed treatment, hand-operated and handheld sprayers, spray equipment mounted on aircrafts or trains, dusters, granular applicators and not handheld wipers. Special questions dealt with the inspection of brand new sprayers. Furthermore there were a few questions regarding special characteristics (e.g. average inspection costs, subsidies, duration of validity, indication by stickers, procedures for brand new sprayers). In view of the framework directive a question was added regarding the body which is responsible for implementing the inspection system. In detail the colleagues were asked for data regarding:

- Number of PAE in use
- Kind of data basis
- Number of PAE inspected in 2013 to 2015
- Basis for requirements for the inspection
- Inspection interval
- Date of 1st inspection
- Need of inspections of brand new PAE (e. g. warranty)
- Proposals where and in which quality new PAE should be inspected
- Existing demands on inspection of brand new PAE
- Existing simplified inspection procedure for brand new PAE
- Obligation of an inspection of new PAE before delivering obligatory in your country
- Body/bodies responsible for implementing the inspection
• Number of current authorized workshops/ official teams and inspectors
• Certificate system of quality control established
• Definitions for a mutual recognition of inspections from other MS
• Penalty if the PAE-owner does not respect the deadline of Nov. 2016
• Kind of PAE where a further SPISE advise is mostly needed
• Expected share of already inspected PAE by November 26th, 2016
• Main problems during the introduction process
• Questions intended to the European Commission concerning the mandatory inspection of PAE in your country

28 of 33 asked countries returned at least partly filled questionnaires. Summarizing all data, it can be stated that the involved countries reported an existence of nearly 2.25 Million of sprayers liable for inspection. This time 20 countries confirmed the already started inspection activities.

This time the result of the survey is particularly interesting due to the upcoming deadline 26th November 2016 by which the Member States have to ensure that PAE in professional use has been inspected at least once.

**Assessment**

The tables 1 to 3 summarize many of the collected data separated for field sprayers and air-assisted sprayers for bush and tree crops.
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<td>2,000</td>
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<td>2,000</td>
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<td>2,000</td>
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Tab. 1: Inspection of field sprayers in the European Countries
<table>
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<tr>
<th>Country</th>
<th>Number of sprayers in use (average 2004-2006)</th>
<th>Number of sprayers inspected (average 2005-2008)</th>
<th>Number of sprayers inspected (average 2009-2010)</th>
<th>After how many years the inspection must be repeated</th>
<th>Average inspection cost (Euro) from... to...</th>
<th>Measurement of vertical distribution of spray by vertical patternator test bench (V) or by nozzle flow rate (N)</th>
<th>Inspection carried out by workshops (W) or official teams (T)</th>
<th>Measurement of vertical distribution of spray by vertical patternator test bench (V) or by nozzle flow rate (N)</th>
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<td>20,000</td>
<td>6,000</td>
<td>3,000</td>
<td>3</td>
<td>120</td>
<td>V</td>
<td>W</td>
<td>V</td>
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<td>1,681</td>
<td>729</td>
<td>729</td>
<td>3</td>
<td>76</td>
<td>T</td>
<td>W</td>
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<td>Bulgaria</td>
<td>1,665</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>100-250</td>
<td>W</td>
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<td>no</td>
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<td>1,372</td>
<td>74</td>
<td>280</td>
<td>3</td>
<td>?</td>
<td>?</td>
<td>W</td>
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<td>0</td>
<td>0</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>W</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,400</td>
<td>0.5</td>
<td>W</td>
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<td>18,679</td>
<td>W</td>
<td>N</td>
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<td>5,967</td>
<td>V</td>
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<td>0</td>
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<td>0.5</td>
<td>W</td>
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<td>0</td>
<td>0</td>
<td>?</td>
<td>?</td>
<td>?</td>
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<td>8</td>
<td>102</td>
<td>3</td>
<td>100-250</td>
<td>3</td>
<td>W</td>
<td>120-170</td>
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<tr>
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<td>671</td>
<td>5</td>
<td>588</td>
<td>3</td>
<td>W</td>
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### Tab. 2 Inspection of air-assisted sprayers in the European Countries (cont.)

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of sprayers in use</th>
<th>Number of sprayers inspected (average 2004-2006)</th>
<th>Number of sprayers inspected (average 2006-2008)</th>
<th>Number of sprayers inspected (average 2009-2010)</th>
<th>After how many years the inspection must be repeated</th>
<th>Average inspection cost (Euro) from...to...</th>
<th>After how many years the first inspection of brand new sprayers is scheduled</th>
<th>Inspection carried out by workshops (W) or official teams (T)</th>
<th>Measurement of vertical distribution by vertical patternator test bench (V) or by nozzle flow rate (N)</th>
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<td>55</td>
<td>50</td>
<td>1</td>
<td>5</td>
<td>?</td>
<td>3</td>
<td>W</td>
<td>N</td>
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<td>Poland</td>
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<td>3.843</td>
<td>3.194</td>
<td>3.579</td>
<td>3</td>
<td>15-30</td>
<td>3</td>
<td>W</td>
<td>N</td>
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<td>Portugal</td>
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<td>180</td>
<td>430</td>
<td>610</td>
<td>5</td>
<td>35 + transp.</td>
<td>5</td>
<td>?</td>
<td>no</td>
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<td>5</td>
<td>?</td>
<td>5</td>
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<td>no</td>
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<td>Serbia</td>
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<td>2</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>100-250</td>
<td>2</td>
<td>T</td>
<td>V</td>
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<tr>
<td>Slovakia</td>
<td>500</td>
<td>80</td>
<td>102</td>
<td>108</td>
<td>5</td>
<td>130-250</td>
<td>5</td>
<td>W</td>
<td>N</td>
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<td>2.958</td>
<td>2.739</td>
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<td>40</td>
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<td>T</td>
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<td>1.133</td>
<td>933</td>
<td>?</td>
<td>4</td>
<td>120-150</td>
<td>5</td>
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<td>250</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>2</td>
<td>~ 400</td>
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<td>W</td>
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<td>675</td>
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<td>4</td>
<td>60-90</td>
<td>1</td>
<td>W</td>
<td>V</td>
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<td>United Kingdom</td>
<td>2.500</td>
<td>850</td>
<td>1</td>
<td>180</td>
<td>before delivery</td>
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</table>
It can be stated that the involved 27 countries reported an existence of about 1.2 Million of field sprayers and nearly 1 Million of air-assisted sprayers. In Italy, France, Poland and Spain are located about 75% of these sprayers. The number of the other kinds of sprayers seems to be rather difficult to state. For all these equipment nearly all data we got were very imprecise.

**Tab.3 Kind of sprayers for which inspection systems exist or will be introduced till 2016**

<table>
<thead>
<tr>
<th>Kind of Sprayers</th>
<th>Austria</th>
<th>Belgium</th>
<th>Bulgaria</th>
<th>Croatia</th>
<th>Denmark</th>
<th>Estonia</th>
<th>Finland</th>
<th>France</th>
<th>Germany</th>
<th>Hungary</th>
<th>Iceland</th>
<th>Ireland</th>
<th>Italy</th>
<th>Latvia</th>
<th>Lithuania</th>
<th>Luxembourg</th>
<th>Malta</th>
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<th>Norway</th>
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With this table it is compiled in which countries and for which kinds of sprayers inspection systems already are introduced or the introduction is already prepared for 2016. As expected all attending countries focus on the field and the air-assisted sprayers. The foggers and the hand-operated sprayers and also the equipments not used for spraying, such as seed treaters, in nearly all countries are seen as objects to be inspected. This applies also for spraying equipment mounted on aircrafts or trains and so on. For handheld and knapsack sprayers nearly all countries use the possibilities of paragraph 3 of article 8 of the directive regarding a derogation. In the meantime the needed risk assessments are already in preparation. This is shown by the coloured table elements.

Doubtless an important key point regarding the mutual recognition is the inspection interval. Here the values range between 1 year in UK and 5 years in 9 other countries. In Italy and Spain for the different regions different intervals are defined. All in one the average inspection interval in the meantime increased from 2.7 years in 2006 to 3.0 years in 2009 to now 4.0 years.

Table 4 shows in which extent the users of air-assisted sprayers take part in the offered inspections. Yearly requested inspections in this case means: Number of sprayers in use
divided by the inspection interval. From this value the percentage of real performed inspections was calculated. Assigned are the results from the time periods 2004-2006, 2006-2008 and 2009-2010. The single columns show that step by step nearly all asked countries are on the way to comprehensive inspections. The share of inspections is increasing in most cases. In some countries the 100 % seems to be reached nearly.

**Tab.4** Yearly inspected air-assisted sprayers as percentage of yearly requested inspections

Concerning the scheduled time of the first inspection of brand new sprayers the answers differs a lot. Due to the fact that some defects (e.g. leakages or internal dirtying) occur directly from the production, Italy, Lithuania and United Kingdom decided that the sprayers shall be inspected before the delivering. Germany and Slovenia report a first inspection time at latest 6 months after the first use.

Furthermore it can be summarized that nearly all attending states follows the rules of EN 13790 till the EN 16122 will be available. Also most states accept minor defects ascertained during the inspection (some only after repair other without repair of the defect too). Meanwhile serious defects in all countries lead to a prohibition of use. Some reported over that a financial punishment for owners of defective sprayers. Nearly all countries prohibit the use for sprayers where a sticker/test report is missing or invalid – that means where a user ignored the last date of inspection. 14 states let perform the inspection by authorized workshops whereas 8 states prefer the system where official teams take this responsibility. The others are undecided in this field.

As inconsistent is to be seen the handling of the measurement of the cross distribution for field sprayers: Some states prefer the usage of the measurement of the coefficient of variation, some others of the nozzle flow rate of single nozzles. And others again utilise both system. The vertical distribution for air-assisted is measured by vertical patternator test benches in 6 countries. Also 6 countries prefer the measuring of the nozzle flow rates here. 13 offer no measurements in this direction.
Finally it can be summarized that countries where fruit/wine growing predominate adjustments or calibrations during the inspection are offered and often well accepted by the users.

The minimum prerequisite for a mutual recognition is to know the addresses of the responsible bodies and the additional an example of the used inspection sticker. In table 5 these essential data are summarized.

**Tab.5 Responsible bodies and examples of stickers of attending countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Address/Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Federal states of Austria</td>
</tr>
<tr>
<td>Belgium</td>
<td>Federal Agency for the Safety of the Food Chain (FASFC) – Boulevard du Jardin Botanique 55</td>
</tr>
<tr>
<td></td>
<td>1000 Brussels</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.afsca.be">http://www.afsca.be</a></td>
</tr>
<tr>
<td>Bulgaria</td>
<td>Technical Control Inspectorate, address: Tzar Boris III 136 blvd., Sofia 1618, e-mail: <a href="mailto:kti@mbox.contact.bg">kti@mbox.contact.bg</a></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Ministry of Agriculture through the SPA</td>
</tr>
<tr>
<td>Denmark</td>
<td>Danish Environmental Protection Agency, Strandgade 29</td>
</tr>
<tr>
<td></td>
<td>DK - 1401 Copenhagen K</td>
</tr>
<tr>
<td>Estonia</td>
<td>Ministry of Agriculture, Lai 39/41, 15056 Tallinn, Estonia, and Agricultural Board, Teaduse 2, 75501 Saku, Harju county, ESTONIA</td>
</tr>
<tr>
<td>Finland</td>
<td>The Safety and Chemicals Agency (TUKES), P.O. Box 66, FI-00521 Helsinki, Finland</td>
</tr>
<tr>
<td>Country</td>
<td>Organization</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>France</td>
<td>MINISTRY OF AGRICULTURE / GIP PULVES (MONTPELLIER)</td>
</tr>
<tr>
<td></td>
<td>GIP PULVES, 361 rue Jean François Breton BP 5095 – 34196 MONTPELLIER Cedex 5</td>
</tr>
<tr>
<td>Germany</td>
<td>Plant Protection Services of the Federal States</td>
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<tr>
<td>Greece</td>
<td>Ministry of Rural Development And Food (Department of Agricultural Mechanization)</td>
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<td>Hungary</td>
<td>?</td>
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<tr>
<td>Italy</td>
<td>ENAMA (Ente Nazionale per la Meccanizzazione Agricola), National Technical Workgroup, Regional Bodies</td>
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<td>Latvia</td>
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<tr>
<td>Luxembourg</td>
<td>ASTA service agri-environnement</td>
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<td><a href="http://www.asta.etat.lu">www.asta.etat.lu</a></td>
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<tr>
<td>Netherlands</td>
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<tr>
<td>Country</td>
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<td>-------------</td>
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</tr>
<tr>
<td>Norway</td>
<td>Norwegian Food Safety Authority, Felles postmottak, Postbox 383, N-2381 Brumunddal.</td>
</tr>
</tbody>
</table>
| Poland      | Inspection of Plant Health and Seed (Państwowa Inspekcja Ochrony Roślin i Nasiennictwa) www.piorin.gov  
Main Inspectorate of Plant Health and Seed Inspection  
email: gi@piorin.gov.pl |
| Portugal    | DGADR (a new organisation of the Ministry is in preparation)  
dspfsv@dgadr.pf                                                   |
| Romania     | Ministry of Agriculture and Rural Development                                                                                               |
| Serbia      | Ministry of Agriculture, Forestry and Water Management - Plant Protection Directorate                                                        |
| Slovakia    | Ministry of the Agriculture,  
Agricultural Technical and Testing Institute in Rovinka (TSUP),  
Central Controlling and Testing Institute in Agriculture in Bratislava (UKSUP)                                               |
| Slovenia    | Phytosanitary administration RS                                                                                                              |
| Spain       | Spanish Ministry is in charge of coordinate and recover all the data. Local authorities have the responsibility to organize the inspection procedure on their area. |
| Sweden      | none yet, probably the Swedish Board of Agriculture                                                                                         |
Conclusions

Summarising all data, it can be stated that the involved countries reported an existence of nearly 2.25 Million of field and air-assisted sprayers (2009: 2.5 Million). 18 countries already carry out a mandatory inspection. All other countries reported that at latest till December 2016 all concerned sprayers will be inspected for the first time.

Especially mentionable is the number of yearly carried out inspections: Since 2004 this number more than doubled from 148 thousand to now 300 thousand in the year 2010.
The PAE inspection in Spain and Catalonia

V.Montemayor¹, A.Goutan²

¹MAGRAMA
²Servei d’Ordenació Agrícola, Subdirecció d’Agricultura, Direcció General d’Agricultura i Ramaderia - Generalitat Catalunya

Article 8 of the Directive on the sustainable use of pesticides clearly specifies that Member States shall ensure that inspections of pesticide application equipment (PAE) are subject to inspections.

The Royal Decree 1702/2011, of November 18th by which the compulsory technical inspection of application equipment for plant protection products in Spain was established, transposes Article 8 and Annex II of Directive 2009/128/EC of Sustainable Use of Pesticides. Since its publication, more than 47,000 inspections have been made in Spain.

The Ministry of Agriculture, Food and Environment (MAGRAMA) coordinates inspections in Spain. Spanish legislation establishes that each Autonomous Community should develop and carry out its inspection program, in order to ensure that all PAE are inspected before the deadline. With more than 100 workshops (ITEAF), most of them private companies, the regional governments have started their inspection programs, estimating that by November 26, 2016 more than 70% of the PAEs will have been inspected. As a result, more than 250,000 equipment will be inspected, which were mandatory registered in the Official Register of Agricultural Machinery (ROMA).

The Ministry of Agriculture, Food and Environment (MAGRAMA) has provided computer applications to support the process. “PRITEAF” is the application to process the information resulting from the measurements and observations made in the inspection. “REGITEAF” is a database in which every inspection is registered. For instance, the records of every inspection carried out are available on a single machine. In addition to these computer applications, the MAGRAMA has published a “Manual of inspections” which collects the inspection procedures for each machine element, and it is based on the published inspection standards.

At present, one of the challenges, especially in certain regions, such as Andalusia, Murcia and the Community of Valencia, is the inspection in fixed installations such as greenhouses and facilities for post-harvest treatment.

Regarding Catalonia, this region has carried out its own inspection program. This program consists in spreading inspections geographically and along the time. It has been based on the PAE registered in the Official Register (nearly 21,000 pieces of equipment). This regional inspection program, which was agreed with the agricultural sector, was started in early 2015. It was accompanied by a communication plan addressed to farmers who have PAE registered or could have any to be registered.

Catalonia is the competent authority to authorize the inspection workshops on its own territory. There is a close relationship between the Authority and the workshops through regular meetings, checking of inspection documents, reports and workshop schedule. Workshops are also inspected according to the control plan in order to ensure the quality of the inspections.

Currently, despite having finished the regional inspection program, Catalonia has only achieved 46% of inspections of the registered PAE. However, it has to be taken into ac-
count that the number of registrations has increased considerably since the beginning of the regional program.

The effort of the Catalonia Government and the good co-operation with the sector has increased exponentially the number of inspected PAE in recent months. Nevertheless, we are still far from achieving the goal of the program before the 26th November 2016 deadline.

The MAGRAMA aims to achieve quality inspections, carried out with accuracy, reliability and traceability. For this purpose, professional firms should be accredited according to the UNE EN ISO 17020: 2012, and their inspection staff should have an extensive training in order to avoid risks to the environment and to the health and safety of workers arisen from the application of plant protection products.

It is also important to possess inspected equipment that allows a uniform and precise distribution of plant protection products without risks, especially so as Spanish agricultural export products not to be affected by lack of fully inspected equipment as establishes Directive 2009/128/EC.
Inspections of in-use Pesticide Application Equipment in Greece

A. T. Balafoutis¹, G. Bourodimos ¹,², Evangelos Anastasiou¹, S. Fountas¹

¹Agricultural University of Athens, Department of Natural Resources & Agricultural Engineering, Iera Odos 75, 11855, Athens, Greece
²Hellenic Agricultural Organisation - DEMETER, Agricultural Engineering Department, Dimokratias Avenue, Ag. Anargiri, Athens, Greece

Summary

Pesticides development during the first green revolution helped agriculture to increase their production and minimize production costs. Almost 60 years later, pesticides use is still of great significance. However, the use of spraying equipment has a major role on the success of pesticide application. Improper or inaccurate spraying application leads to cost increase of production costs, waste of agrochemicals, limited pest control, excessive spray drift and environmental and crop damage. Law 4036/2012 which embodies the provisions of Directive 2009/128/EC into Greek legislation establishes the regular inspection of the in-use Pesticide Application Equipment (PAE). Aim of the current study is to present the inspection system of in-use PAE that was developed due to the aforementioned law. Specifically, the role of every PAE stakeholder and the transactions that take place between stakeholders are defined. Finally, the methodology that is followed for conducting the inspections is described and the results until now are presented.

Introduction

An enormous amount of 3 billion kg of pesticides are used every year in agriculture consisting a 40 billion US$/year market (Pimentel, 2005). The pesticides have resulted in increase of crop quality and productivity since their first use during the first green revolution. However, pesticides have been found to be the source of major environmental and human health problems due to their transport from crop-growing areas to rural and urban areas through air, water and other natural resources (Gil and Sinfort, 2005). While bystanders, livestock, terrestrial and aquatics ecosystems may are exposed to pesticides through the spray drift (Hilz and Vermeer, 2013). Due to the aforementioned problems, European Union set rules for the sustainable use of pesticides to reduce the risks and impacts of pesticide use on people's health and the environment through Directive 2009/128/EC. Greece wasn't compliant with this directive until recently.

Law 4036/2012 which embodies the provisions of Directive 2009/128/EC into Greek legislation, establishes the regular inspection of the in-use Pesticide Application Equipment (PAE). Until 26 November, 2016, at least one inspection of the equipment must be carried out. The sprayers that will be inspected in 2016 will be rechecked in 2020 and then every three years, while the sprayers that will be tested for the first time in 2017 or later, will be rechecked every 3 years. Namely, the equipment that will be tested in 2017 will be rechecked in 2020, that of 2018 in 2021 etc.

The Directorate for the Management of Land Reclamation Works and Mechanisation of the Ministry of Rural Development and Food (MRDF) is defined as the authority responsible for the regular inspection of professional PAE.

According to the Hellenic Statistical Authority (HelStat), in 2010 there were 106,485 mist blowers and 49,044 boom sprayers in Greece. These figures are unsafe for their accuracy as they are based on statistical analysis and up to this day, at the request of the MRDF,
45,000 sprayers of the two aforementioned types have been registered at the Regional Agricultural Equipment Inventory Services (RAEIS).

**Materials and Methods**

*Inspection system of in-use pesticide application equipment*

According to the decision no E8 1831/39763, law 671/B/21-4-2015 of the Deputy Minister of Productive Reconstruction, Environment and Energy, a system of periodic inspection of PAE is established in Greece, which leads to an inspection certificate and appropriateness sticker mark.

According to the above Ministerial Decision:

- Minimum requirements in personnel and equipment are established, and must be met for the authorization of the Pesticide Application Equipment Inspection Stations (PAEIS).
- The Agricultural Engineering Department of the Institute of Land and Water Resources (formerly Institute of Agricultural Machines & Constructions) of the Hellenic Agricultural Organization - "Demeter" is defined as the Reference Laboratory of Inspections.
- Portable Pesticide Application Equipment and Knapsack sprayers are excluded from inspections, unless in case this equipment is assessed as a risk to human health and the environment.
- The new PAE, purchased after October 21, 2015:
  - is delivered to the buyer, under the responsibility of the dealer of the equipment, provided with inspection certificate and appropriateness sticker mark.
  - is not necessary to have inspection certificate and appropriateness sticker mark, provided that a PAE of the same type has been certified in a qualified domestic or foreign Institute, according to EN 12761/1-3 or ISO 16119/1-4. In this case it must be accompanied by a Declaration of Conformity by the manufacturer.

![Diagram](image.png)

*Fig. 1. Interactions between the stakeholders of the national inspection*
Reference Laboratory of Inspections (AgEng Dept of DEMETER)

The Reference Laboratory of Inspections is responsible for:

- The authorship of the instruction of PAE inspection manual to be used for carrying out inspections.
- Assigning a unique registration number to each PAEIS authorized to perform inspections and keeping a nationwide PAEIS registry.
- Initial audit of PAEIS and issuance of practice proof to grant authorization.
- Audit of the process and quality of PAE inspections by carrying out sampling inspections in all registered PAEIS.
- In case of not meeting the audit requirements, propose to the RAEIS the withdrawal of authorization of the non-complying PAEIS and inform MRDF for the imposition of sanctions.

Regional Agricultural Equipment Inventory Services (RAEIS)

The Regional Agricultural Equipment Inventory Services are responsible for:

- The maintenance, updating and management of the Pesticide Application Equipment Registry (PAER) into which all in-use PAE and the results of the inspections performed by PAEIS are registered to.
- Issuing authorization of PAEIS according to the control practice of the reference laboratory.
- Shipment of the updated registry and a copy of each PAEIS authorization to the Reference Laboratory of Inspections and the Directorate for the Management of Land Reclamation Works and Mechanisation of MRDF.
- Informing MRDF on the results of inspections and of cases of non-compliant PAE.
- The withdrawal of the authorization the PAEIS indicated by the Reference Laboratory of Inspections as non-compliant.

Pesticide Application Equipment Inspection Stations (PAEIS)

The PAEIS can operate in fixed or mobile installations and may be public and/or private that belong to natural or legal entities, such as plant protection machinery manufacturers, pesticide stores, University or Technological Educational Institute departments, Agricultural Cooperative Organizations or departments of the MRDF etc.

The PAEIS are controlled by the Reference Laboratory and that control is related to staff, equipment and inspection methodology. The initial inspection cost is 1700€ plus VAT and the annual monitoring cost 300€ plus VAT.

The PAEIS operate under authorization of the RAEIS of the Region in which the head office is established, provided that the appropriateness of the PAEIS is explicitly mentioned in the record of the Reference Laboratory. Using this authorization, the PAEIS can perform controls throughout the country for five years.

The PAEIS is obliged to inform the RAEIS and the Reference Laboratory of Inspections of the inspections results that have been carried out, keep inspection records and cooperate with the Reference Laboratory of Inspections on possible control.
The PAEIS must have the necessary employed staff to carry out inspections, comprised at
least by one person called inspector. The inspector may be Agronomist, Mechanical En-
gineer, holder of MSc or PhD in Agricultural Engineering, Technologist Agronomist, Tech-
nologist Mechanical Engineer etc. The inspector is present at every PAE inspection and is
responsible for carrying out inspections, preparation of inspection certificates, granting of
the appropriateness sticker mark, calibration of equipment, etc.

In order for the inspections to be carried out by the PAEIS, the suitable equipment should
be present. The equipment and the instruments used during inspections should be cal-
ibrated by official calibration bodies that have been accredited by the Hellenic National
Accreditation System (HNAS) or by foreign corresponding official calibration bodies. The
equipment used should include:

- Length measuring instruments
- Pressure gauges control device
- Precision pressure gauges, for determining the pressure loss of the tubes
- Tools and suitable adaptors to allow connection of various control devices with
  the equipment inspected.
- Device for measuring the flow of nozzles which can be either:
  i. Manual and individual equipment. Calibrated volume container and timer
  ii. Equipment performing the measurements on the machine. Instrument for
determining the flow of nozzles
  iii. Equipment that requires removing the nozzles from the machine. Inspec-
tion table for nozzle flow inspection
  iv. Table to measure the uniformity of distribution (automatic or manual,
  fixed or scanning)
  v. Timer, collector and scale.
- Devices for measuring the pump flowrate ability:
  i.  Flowmeter or
  ii.  Precision pressure gauges.
- Electronic document with the data and the results of inspections.

Owner of in-use PAE

The owner of in-use PAE should ensure:

- The recording of the PAE in the PAER.
- The inspection of the PAE in a PAEIS of his choice.
- The replacement of any deficiencies regarding the PAE found during the inspec-
tion, in which he must be present.
- Submitting a declaration in PAEIS which is sent to RAEIS, that he will not use
  non-compliant PAE until its successful inspection or that he is willing to delete
  this PAE from the PAER.
- The maintenance, good working condition and proper calibration of the PAE be-
  fore each application of pesticide, in the intervening time between regular in-
spections.
Methodology—procedure of inspections

The PAEIS are required to carry out the inspections of PAE according to the inspection manual of the Reference Laboratory of Inspections and the requirements of Directive 2009/128/EC.

The inspection manual of the Reference Laboratory specifies the requirements and the methods to ensure that those requirements are met during inspection of in-use PAE and has been prepared in accordance with European standards EN 13790-1:2003 and EN 13790-2:2003. Because of the replacement of EN 13790 with EN ISO 16122, a new version of the manual will follow (at the end of 2016 approximately) which will be based on EN ISO 16122 (only a few differences occur between the two standards) and on the first results of inspections of PAEIS.

The basic check points of boom sprayers and mist blowers are:

- Power Transmission Components
- Pump
- Stir set-up
- Sprayer tank
- Measuring, control and regulation systems
- Pipes and hoses
- Filters
- Spray arm (boom sprayers)
- Nozzles
- Distribution
- Fan (mist blowers)

After completion of the PAE inspection, the inspected equipment is classified into one of the following four categories:

- **CATEGORY I**
  In this category are included PAE that meets the requirements of Directive 2009/128/EC and Law 4036/2012. Inspection Certificate and sticker mark are granted, and the sticker mark is placed at a prominent spot.

- **CATEGORY II**
  In this category are included PAE showing minor deviations from Directive 2009/128/EC and Law 4036/2012. An Inspection Certificate listing the deviations and the obligation to correct them until the next inspection is issued along with the sticker mark, which is placed at a prominent spot.

- **CATEGORY III**
  In this category are included PAE that vary considerably from Directive 2009/128/EC and Law 4036/2012. Not sticker mark is granted and its use is prohibited. A Inspection Certificate is issued listing the discrepancies that must necessarily be corrected in case of a new inspection, in order to be able to be classified as category I or II. The owner has to sign a declaration, to the responsible PAEIS which is then sent to RAEIS, attesting that will not use the equipment until its successful inspection.

- **CATEGORY IV**
In this category are included PAE that has been included in Category III and whose owner signed a declaration attesting that he wishes to delete the equipment from the PAER and that he does neither intend to repair nor to use it.

**Results**

In Greece from 2015 until today, 57 PAEIS have been authorized. All operate on mobile facilities and the majority is of private interest (only 2 have been established by public Technological Educational Institutes). There is strong interest from individuals and it is estimated that by the end of the year approximately 90 PAEIS will be established.

While the number of the established PAEIS is considered satisfactory, this is not the case for number of spraying machines that have been tested which amounts to 100 PAE.

This is mainly due to the unwillingness of farmers to have their equipment inspected. The inspections and certifications are not a common practice among Greek farmers or manufacturers, and despite the fact that the inspection is mandatory, currently the response is low. Another problem is the poor state of in-use PAE, which combined with the poor economic situation in Greece, discourages farmers from having their spraying machines inspected and repaired. It should be noted that the inspection costs around 100 € on average, while the average cost of repair of the machinery from the so far collected data amounts to 300€.

The MRDF is trying to cope with the whole situation in various ways, such as financial penalties (ranging from 1000 to 30000 Euro), connection of the pesticide market with inspection certificates and sustainable use of pesticides certificates etc. It should be noted that for the success of the whole procedure, prerequisite is the acceptance of the Greek farmer and his participation in the whole process of inspections.

**Conclusion**

In Greece, the lack of information of farmers on the subject, combined with the high cost (for the current economic situation) of compliance which will be required to be met by the owners of the PAE, greatly increases the difficulty of the inspections of in-use pesticide application equipment. The scientific community and the state should try to deal with the precaution with which farmers face the need for certification of their sprayers. Greek farmer needs to be informed about the mandatory check of in-use pesticide application equipment and the impact of its misuse and realize that the cost is relatively small, considering the benefits due to reduced application of pesticides, production of quality products, and also the safety and protection of his health and the environment.

**References**


ISO/AWI 16122-5. Agricultural and forestry machines - Inspection of sprayers in use - Part 5: Aerial spray systems -- Environmental protection.

HELLENIC STATISTICAL AUTHORITY. http://www.statistics.gr
The point of view of a farmer

C. González¹

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Introduction

I would like to thank Mr Emilio Gil and the organisation for inviting me here and to give Copa and Cogeca the opportunity to present the point of view of European farmers and agri-cooperatives. In addition, it is with great pleasure that I am here as former ESAB and Emilio Gil student and I want to take this opportunity to thank him for all his effort when I was at this School.

Copa and Cogeca are the united voice of farmers and their cooperatives in the European Union and therefore, I would also like to take this opportunity to slightly amend the title of this presentation, as I am not here representing a single farmer but 23 million farmers and their families and 22,000 European agri-cooperatives.

Copa and Cogeca represent 66 Member organisations and 34 Partner Organisations from 27 Member States and operates in 6 working languages (EN, FR, ES, DE, IT, PL). Our mission is to ensure a viable, innovative, competitive EU agriculture and agri-food sector capable of meeting growing food demand.

Copa and Cogeca Secretariat is organised in different departments, covering horizontal policies such as phytosanitary questions, environment, food chain or rural development and sectorial working parties such as cereals, fruits and vegetables, pigmeat, among others. In practice, we cover almost all agricultural productions.

Legislative framework

The main basis for our work in the framework of sprayers and application of Plant Protection Products (PPPs) is the so called “Pesticides package”.

In 2009, a Pesticides Package was adopted by Member States and European Parliament, consisting of four pieces of legislation:

- Directive 2009/127/EC amending Directive 2006/42/EC with regard to machinery for pesticide application
- Directive 2009/128/EC on the sustainable use of pesticides, establishing a framework for Community action to achieve the sustainable use of pesticides (Sustainable Use Directive);
- Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market. The purpose of this Regulation is to ensure a high level of protection of both human and animal health and the environment and to improve the functioning of the internal market through the harmonisation of the rules on the placing on the market of plant protection products, while improving agricultural production;
- Regulation (EC) No 1185/2009 concerning statistics on pesticides. This Regulation sets out rules for collecting information on the annual quantities of pesticides placed on the market and used in each Member State.

This pesticides package aims at reducing the use of pesticides, ensuring high safety standards for consumers, protecting residents, bystanders, workers and farmers that apply
PPPs or live nearby areas of application and preventing risks for the environment from the adverse effects that some PPPs may have. The whole package is based on the precautionary principle.

Other pesticide-related EU legislation concerns labelling of PPPs and chemicals, pesticide residues in food, feed and water or organic farming.

As a result from the application of the package, many active substances have been phased out from the market and many restrictions and mitigation measures have been imposed to farmers, operators andappers (e.g. aerial sprayer, ban on neonicotinoids).

Finally, there is another piece of legislation which is of relevance for pesticides: the Water Framework Directive (Directive 2000/60/EC establishing a framework for Community action in the field of water policy). Based on this Directive, additional substances have been banned due to the risk of contamination of water.

**Sustainable Use Directive**

This Directive establishes a framework to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of Integrated Pest Management (IPM) and of alternative approaches or techniques such as non-chemical alternatives to pesticides. Aerial crop spraying is banned as a general rule, and no spraying at all is allowed in close proximity to residential areas.

In order to achieve these objectives, all Member States must set up National Action Plans in which they set “(...) quantitative objectives, targets, measures, timetables and indicators to reduce risks and impacts of pesticide use on human health and the environment and to encourage the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides (...)”.

Also as part of the Directive, “(...) Member States shall ensure that all professional users, distributors and advisors have access to appropriate training by bodies designated by the competent authorities. This shall consist of both initial and additional training to acquire and update knowledge as appropriate (…)”.

The official certifications vary from Member State to Member State even if in general lines, the main areas are always the same. However, as there is not a common certificate or document in the European Union which certifies that the person who sells and the person who buys hold the competent certificate, there is uncertainty when delivering those products (especially if the persons holds a certificate from another Member State).

About technical check of spraying equipement, “(...) Member States shall ensure that pesticide application equipment in professional use shall be subject to inspections at regular intervals. The interval between inspections shall not exceed five years until 2020 and shall not exceed three years thereafter (…)”. Moreover, “(...) by 14 December 2016, Member States shall ensure that pesticide application equipment has been inspected at least once. After this date only pesticide application equipment having successfully passed inspection shall be in professional use (…)”.

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1. Integrated pest management’ means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment.
As for application of PPPs, “(...) Member States shall ensure that appropriate measures to protect the aquatic environment and drinking water supplies from the impact of PPPs are adopted. Those measures shall support and be compatible with the relevant provisions of Directive 2000/60/EC and Regulation (EC) No 1107/2009 (…)”.

Finally, there are some provisions about handling and storage of PPPs “(...) Member States shall adopt the necessary measures to ensure that the following operations by professional users and where applicable by distributors do not endanger human health or the environment: (a) storage, handling, dilution and mixing of PPPs before application; (b) handling of packaging and remnants of PPPs; (c) disposal of tank mixtures remaining after application; (d) cleaning of the equipment used after application; (e) recovery or disposal of pesticide remnants and their packaging in accordance with Community legislation on waste (…)”.

Copa and Cogeca position

As already stated the whole legislation is based on the precautionary principle, thus leading to a more restringent framework. Whilst Copa and Cogeca acknowledge the need to reduce any risk to the environment through pesticide use and water contamination, we have grave concerns over the continuous loss of active substances and PPPs which puts agricultural sustainability at risk.

It is essential that equipment used for spraying agrochemicals is inspected on a regular basis, whether by the farmer themselves (or their staff) or at a special station. The development, implementation and timescale for lowcost testing schemes need to be discussed and agreed upon with the stakeholders involved at national level. Putting new application equipment and technology into practice for reducing spray drift and PPPs use should be given particular support.

There have been some examples of good practice in different Member States since 2009:

- **Austria** – Technical checks of spraying equipment take place at regular intervals as part of ad-hoc workshops. Financial contributions are made within the rural development programmes.
- **Belgium** – Legal requirements are already in place for the mandatory inspection of spraying equipment by an official body and handling and storage of PPPs, including the need for a warning sticker on the entrance of storage rooms.
- **France** – Since 2009, a technical inspection by an officially approved institution is periodically required. Anti-drift material and equipment for wastewater treatment are also controlled by the competent authorities.
- **Germany** – Mandatory inspections take place periodically within a network of test centres. There are several examples of efficient use of PPPs through directed nozzles, controlled sensors and assay techniques. Directed nozzles enable the percentage of drift to be reduced and avoid reaching fishing areas and non-targeted areas.
- **Hungary** – All spraying equipment, within a certain cubic capacity must be certified by a competent authority. A Certified Pest Protection Machinery Catalogue of all machinery is published on a regular basis to inform all professional users of available and approved machinery.
- **UK** – The National Sprayer Testing Scheme (NSTS) was set up in 2001 as a voluntary sprayer testing scheme and in 2009-2010 sprayers accounting for the majority of
the sprayed area in the UK were tested under this scheme. Tests are carried out on farm by approved testers. For smaller pesticide users a self-test option is available. Despite all efforts, deadline is approaching and still in many parts of Europe the workload to check the machinery is high. In some regions, it has barely started. Some of the reasons to explain such delay may be the lack of appropriate systems in place or the reluctance of some farmers to engage with the system.

We want also to point out that even if the deadline for the checks is approaching, farmers should not be confronted with the possibility of not treating the crops due to mandatory scheduled checks. In addition, the winter season and its reduced need to treat crops will most probably increase farmers’ availability to perform the inspections.

In those cases where there is reluctance from farmers to engage, we have already seen that authorities have not accurately explained the benefits of the checks and in many cases, these checks are seen as another burden.

In this respect, we should not forget the high competition from third exporting countries which usually do not respect the same environmental standards than European farmers. Trying to reduce the impact on European farmers’ competitiveness while respecting the environmental requirements should be a priority for European authorities.

Proper explanations about both economic and environmental costs of not applying PPPs correctly are most probably the best way to engage farmers in the system. As a matter of example, Copa and Cogeca are collaborating with the European Agricultural Machinery Association (CEMA) and the European Crop Protection Association (ECPA) on different projects aiming at tackling pesticide use risks for water and the environment.

We would like to highlight a first project on sprayers, which will help farmers and dealers to chose the most suitable nozzle based on individual farmer machinery and the information available. This tool may help to reduce drift as well as to ensure a high level of competence when choosing the appropriate nozzle.

The other project we are engage relates about closed transfer systems and aims to reduce the risk for exposure from farmers and operators when loading and downloading the bottle with pesticides in the tank. These systems may also help to reduce the risk for the environment.

Closing remarks
As the united voice of EU farmers and agri-cooperatives, Copa and Cogeca want to express their engagement with the high quality and environmental standards of EU production and we will continue to support the EU system.

In this respect, we want to fully support all the efforts made and that will be made to reach the deadline for inspections and when this will not be possible, to put in place appropriate solutions that satisfy both the environmental goals and the need to treat the crops in due time.

We also want to express our interest to reduce red tape and simplify the whole policy framework, as this reduces our competitiveness and our capacity to compete with third exporting countries which do not follow the same high quality standards.

Finally, we want to express our commitment with market and consumer expectations. In this respect, we are open to collaborate with the other stakeholders that might be involved in this discussion to find the best solutions that suit for purpose.
Session 1

Inspection of brand new sprayers

SPISE position and proposal

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After the publication of Sustainable Use Directive (SUD) (128/2009/CE) late October 2009, the inspection of all sprayers in use in EU became mandatory. As a result of that, the mandatory inspection of sprayers in use has been arranged with the main objective to fulfill the requirement established by the SUD, which is to inspect all sprayers in use by end 2016. As a consequence of this initiative, and again at different level of concurrence, it has been detected that still can be found in the market sprayers not too very old (even new sprayers) which do not fulfill the minimum requirements established for sprayers in use (EN ISO 16122 series). This fact has generated in most cases uncomfortable situations for the technicians/Directors of the inspection’s workshops which must reject the sprayer due to faults that do not derivate from the use of bad maintenance, but from an inaccurate manufacturing process or design. Some examples can be mentioned as inaccurate manometer, bad position of tank level indicator, no filter in pressure side, pressure drop, or no instruments to the machinery to check the correct functioning of the machinery, etc. It seems therefore appropriate that essential environmental protection requirements for the design and construction of new machinery for pesticide application, as included in the Directive 2009/127/CE, must be fulfilled while ensuring the consistence and accomplishment of those requirements relating to the mandatory inspection of sprayers in use.

The SPISE community, through its Technical Working Group 1 – Certification of New Sprayers, has been working in the last years with the main objective to find an accurate solution for the above scenario. Several approaches and meetings have been already held between sprayer’s manufacturers and SPISE core with the aim to find a common, valuable and practical solution. It is true that there are large differences among manufactures, not only in terms of size and business, but also considering their capabilities and updating concerning the framework legislation. Self-Certification and CE mark does not guarantee, at least not in all cases, that the intended pesticide application equipment (PAE) accomplishes all the legal and mandatory requirements.

Considering the previous scenario, the SPISE Community proposes to CEMA that, in order to avoid all the above mentioned problems, every single sprayer should be checked in the factory (dealer, distributor), following the harmonized standard EN ISO 16122-series. It is clear that this harmonized standard should be adopted for new sprayers. This procedure can help the manufacturers to guarantee the total accomplishment of the requirements that will be required to the farmer. And this procedure, also, will improve the objective, high quality and very professional quality control already established in the most of sprayer’s companies. The only way to assure the correct functioning of the whole PAE is by checking the entire machine before taking into use. SPISE Community offers to CEMA all the support in providing an agreed advice document in order to help all the sprayer’s manufacturers to follow an accurate inspection of all their PAE production. These actions
will hopefully avoid some of the problems encountered and will help the manufacturers to follow the legislative European framework of sprayer’s inspection.
Industry proposal on the inspection of sprayer in use (preliminary inspection)

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Summary
The placing on the market and in-use compliance of sprayers is covered by European legislation. Some customers, dealers and importers want to be doubly sure that the new sprayer will pass the first inspection for sprayers in use and that the sprayer is accompanied with a national test report and decal as proof of compliance. It is not a legal requirement. The leading European sprayer manufactures represented in CEMA have a proposal to harmonise such optional individual sprayer proof of compliance by means of mutual recognition of national test reports and decal. The manufacturer, as authorised test centre, adopts the suitable test protocol. The precondition for the authorisation is a verification and agreement of the manufacturer’s test protocol by the authorisation body of a Member State. A local authority decal will be applied. A CEMA decal supports the mutual recognition between the authorisation bodies.

Keyword: preliminary inspection, new sprayers, CEMA decal

Situation
The leading European sprayer manufacturers represented by CEMA have always worked along a clear vision and strategy to ensure the safety and health of the operator and the protection of the environment, while satisfying the customer demands for functionality, versatility, operability, etc. Therefore, in addition to the efforts in product development the industry, together with the other stakeholders, has drafted the harmonised European standard EN ISO 16119 for placing sprayers on the EU market and as second step the harmonised European standard EN ISO 16122 for inspection of sprayers in use. Standardising the requirements and methods for inspection of sprayers in use takes into consideration not only the original performance of the sprayer but also its use, care and maintenance. This is a logical link to ensure the continued benefit arising from the supply of new sprayers of good quality and with all officially demanded features.

What are the current steps in the process of approval and in-use inspection today?
The self-certification (module A) according to the Machinery Directive, which is usually based on the EN ISO 16119, is an obligation for the manufacturer. It is part of the declaration of conformity and it is identifiable on the machine by the CE mark.

The Declaration of Conformity is the formal and legal statement addressed to authorities that the individual machine complies with the Machinery Directive under self-certification. The inspection of sprayers in use according to EN ISO 16122 (formerly EN 13790) must be carried out by an authorized test centre. The first inspection must take place not later than 3 / 5 years after placing on the market.

Problem
Compliance for new sprayers with EN ISO 16119 includes higher performance requirements then EN ISO 16122, but customers, dealers and importers want to be doubly sure...
that the new sprayer will pass the first inspection for sprayers in use. Therefore they prefer that the new sprayer will be delivered with the certificate showing compliance with the national demanded test level, which can be on different levels either following the EN directive 128 (Sustainable Use Directive) or EN ISO 16122 or EN 13790. This includes for the customer a national test report and decal.

The first inspection, according EN ISO 16122 or EN 13790, of the sprayer can be offered by the manufacturer as an additional service, i.e. in terms of an optional item in the product catalogue (as already done today in various Member States), but there is no mutual recognition of national test reports across all member states, due to different reasons. Already the link to the EU directive 128 (Sustainable Use Directive) where the sprayer in use inspection is based on is interpreted different by the different Member States.

Individual sprayer inspections for each Member State would be the worst case scenario, difficult or impossible to be managed and therefore it would be rejected by the industry.

**Proposed Solution**

The (first) inspection is offered by the manufacturer as an option – it is not an obligation. It is up to each individual customer to decide whether or not he likes to accept and to buy this offer as option.

Upon a request, the manufacturer shall be approved as an authorized test centre by an authorization body of one Member State, in order to carry out officially recognized sprayer inspections.

The test reports and certificates issued by any authorized test centre (including an authorized manufacturer) shall be mutually recognized. This mutual recognition is a mandatory requirement according to the Sustainable Use of Pesticides Directive!

**CEMA Approach in detail**

There is a test protocol based on the EN ISO 16122 adopted by a manufacturer. The test protocol can be specifically written for the manufacturing facility (tailored to the man-
ufacturer depending on the level of integration of the Certificate of Production into his manufacturing processes). It is referred to as the manufacturer’s test protocol.

The manufacturer can choose for its authorisation as test centre an authorisation body which is located at the manufacturer’s facility place (county, province or state), or it can be an authority from one of the different EU member states. The selected authority is asked to verify whether the Manufacturer’s test protocol is fulfilling the requirements of EN ISO 16122 and whether it can be agreed, with or without certain modifications, as equivalent of the test protocol from the testing authority. The authorisation as test centre is dependent on this agreement.

The selected authority may visit and inspect the manufacturing facility (to check items related to EN ISO 16122 only). The manufacturer will conduct the testing of the sprayer according the test protocol and will be authorized to issue the testing report and place the local authority decal on the machine.

The manufacturer will pay fees related to the approval as test centre.

The different national schemes (authority, testing records and decals) will be kept as they are today.

The CEMA decal can be attached by the manufacturer as a sign that above procedures are followed and as support for the mutual recognition. A solution for national test reports and decals could then still be done locally following the local procedure or registration process, but a new test should not be done to get this national documents! Here it is a great help to have a national responsible contact to get this process better organised.
Inspection of new sprayers – defects following EN-ISO 16119/16122

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During the last years of testing we have noticed, that more and more sprayers of the low price segment appear in the market. These sprayers are equipped very poor and sometimes regular facilities, according to ISO 16119, are even missing.

In different countries of Europe there are different intervals for the testing of brand new sprayers for example:
In Germany within the first 6 month after putting in operation
In Austria 5 years after buying

So, if a farmer buys such a machine without sticker, in Germany the mistakes can be detected within half a year and the dealer must bring it in the right condition during the time of warranty. Precondition is that the farmer and the tester know ISO 16119 and can force the dealer to bring it in the right form according to ISO 16119.

But what will happen if dealer and tester are the same company or even the same person?
In Austria the farmer gets passed the buck, as after 5 years of use no dealer will give any warranty.

In many European countries it is similar. It is a kind of blind confidence for brand new sprayers. A control for fulfilling ISO 16119 is either not existent or ineffective.

In the market there are sprayers, which ex-factory do not fulfill ISO 16119, but they can be taken into use totally legal.

But sometimes even such poor equipped sprayers are sold with stickers. It is not legal, as sometimes important parts according ISO 16119 are missing.

If such a machine joins the test of sprayers in use after 3 years, the tester can only complain the existing parts which are there, because the regimentation allows the tester only to test the parts which are in the machine and not the testing according ISO 16119.

For insufficient equipment of brand new sprayers in Germany the “Marktaufsicht” is responsible. These persons are also responsible for toaster, razor, toys etc. They just do not know the special demands of a sprayer, but have to judge about the right equipment. They also do not have the devices to test for example whether the pump is big enough for the requests of the sprayer.

The reason, why insufficient brand new sprayers can be placed in the market, is if they are tested in use after being sold, they simply have to pass the test of sprayers in use following ISO 16122 following ISO 16122 to get a sticker, and have not to be tested if they fulfill EN-ISO 16119.

The farmer must be aware to the features according to ISO 16119 to initiate a process with the “Marktaufsicht”, when he got a bad equipped sprayer.

But - if a farmer wants to buy a cheap sprayer - does he indeed want to initiate such a process?

Some examples:
Fig. 1 A sprayer on Agritechnica 2015 Clear water tank for cleaning missing, agitator missing, bypass deactivation missing, internal cleaning missing, barrier for suction filter missing.

Fig. 2 Agitator deactivation and bypass deactivation missing (it is not possible to empty the sprayer complete), internal cleaning missing.
During the last years of testing we have noticed, that more and more sprayers of the low price segment appear in the market. These sprayers are equipped very poor and sometimes regular facilities, according to ISO 16119, are even missing.

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In Austria the farmer gets passed the buck, as after 5 years of use no dealer will give any warranty. In many European countries it is similar. It is a kind of blind confidence for brand new sprayers. A control for fulfilling ISO 16119 is either not existent or ineffective.

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But - if a farmer wants to buy a cheap sprayer - does he want to initiate such a process indeed?
Session 2

Definition of a common risk assessment procedure for Pesticide Application Equipment (PAE) to be exempted from the inspection

Introduction

The European Directive 2009/128/EC on the sustainable use of pesticides (SUD) states that Member States (MS) shall establish an inspection at regular intervals of all pesticide application equipment (PAE) in professional use. In addition, MS shall ensure that all PAE in professional use has been inspected at least once by 26 November 2016.

For certain types of PAE, Article 8/3 of this Directive 2009/128/EC allows the MS to derogate from the mandatory inspection at regular intervals or to apply a different timetable and inspection interval based on a risk assessment for human health and environment and an assessment of the scale of use.

Since the implementation of the SUD, the SPISE community looked into this issue and worked on this open door to derogation of the mandatory inspection. The first reason is the large scope of the SUD which requires the inspection of all types of PAE by the end of 2016. It is a matter of fact, that most of the MS will be able to reach this deadline for the common and most used PAE as boom, orchard, vineyard and greenhouse sprayers. For other PAE based on other functioning principle and of a low scale of use (foggers, handheld sprayers, spray lances, granule spreaders, sowing equipment, etc.), derogation or postponement to mandatory inspection would be welcome. The second reason is the few instructions given by the SUD on the risk assessment. Any clear procedure or protocol is proposed to the MS. Moreover, even the basic rules of risk assessment are generally common; they are as much risk assessment procedures as study cases. Therefore the SPISE determined the need to develop a common risk assessment protocol while at the end the result would be different from MS to another considering the local use.

Background

The SPISE 3 (Brno, 2009) has been focused on the analysis of the new SUD recently adopted in January 2009. Each requirement of the Article 8 of the Directive has been presented, dissected and discussed. Already, a specific session has been dedicated to the Article 8/3, and numerous questions were raised from the debate around this subject. In conclusion, the SPISE working group has been asked to clarify the concept of Risk Assessment, to improve and feed the classification scheme of the sprayer and to establish a kind of list of priority concerning the development of new inspection standards (Huyghebaert and Bjugstad, 2010).

Three years later during the SPISE 4 (Lana, 2012), the session 2 related to Article 8/3 of the SUD has been focused on the clarification of the concept of the Risk Assessment (Huyghe-
baert and Bjugstad, 2012) and a first approach or Risk Assessment for Human Health and the Environment related to PAE has been proposed (Ganzelmeier, 2012). It has been defined that Risk Assessment is an overall process consisting of a series of logical steps to enable, in a systematic way, the analysis and evaluation of the risks associated, in our case, to the use of a non-inspected PAE (ISO 12 100, 2010). Finally, Ganzelmeier and Gil (2012) proposed a first classification of the PAE in professional use covered by the SUD. The SPISE community decided also to create Technical Working Groups (TWG) aiming at solving the remaining issues. One of them is specifically dedicated to the definition of a common risk assessment procedure for excluding PAE from the inspection (TWG 2).

During the SPISE 5 (Montpellier, 2014), the TWG2 reported two main results. Firstly, an inquiry carried out on the National Action Plan (NAP) showed that most of the MS didn’t take into consideration the derogation based on the Risk Assessment. Very few information is given in the NAPs about that subject (Huyghebaert and Bjugstad, 2015). Secondly, Wegener (2015) proposed a common risk assessment procedure based on the Zürich-methodology. Even if this proposal is perfectible, it allows MS to run a first qualitative risk assessment and then determine priorities in the implementation of their inspection scheme. The SPISE community decided that the outcomes of the TWGs’ discussion would be materialized into reference document called SPISE Advice.

**Current state**

An international enquiry has been directly addressed in 2015 to the SPISE community in order to determine the state of progress of the implementation of the SUD in the MS and specifically the Article 8/3 and the issues like derogation, risk analysis, scale of use PAE… The aim was to gather exhaustive information on the topic “Risk Assessment”. The survey was addressed to 92 representatives from 25 countries of the EU (Cyprus, Estonia and Malta have not been contacted due to lack of contacts). Only 19 experts gave an answer. Therefore the results of this survey are relevant but nevertheless incomplete and sometimes inaccurate. The lack of response indicates that the MS hardly manage issues tackled by the survey (Risk Assessment, scale of use, calibration of inspection equipment…).

This enquiry was part of a preliminary study of the Belgian project SIRA-APESTICON. This project aims at the development of this Risk Assessment for PAE in Belgium and finally to answer to the EU Directive 2009/128/EC requirements. Objectives are to develop and validate a Risk Assessment (RA) protocol, apply the RA protocol on the PAE in use in Belgium, develop inspection protocols according to the RA protocol for the PAE in use not subject to exemption and not subject to inspection for the moment. This project is still running and the first results will be given during the SPISE 6 in Barcelona.

In the meantime, a SPISE Advice has been developed and proposed to the Spise Working Group (SWG). This document is based on the work done by J. Wegener and will be proposed to the Spise community during the SPISE 6 in Barcelona. This SPISE Advice is a first proposal which will be amended with the results of other current researches.

**Open issues**

Although Risk Assessment concept and basic principles are well-known, it is a matter of fact that to each study case, a new Risk Assessment procedure should be developed to fit the issue. It hasn’t been possible to find a tailor-made Risk Assessment procedure for the inspection of the PAE and for that reason a risk assessment has been developed in a prac-
tical and harmonized manner on European level. This derived risk assessment procedure has been proposed by Wegener and al. (2015) and will be subject to a SPISE Advice. This proposal is a first approach which gives to the MS a practical tool to determine which type of PAE has a low, a significant or a high risk with regard to human health and the environment form a technical point of view on a qualitative measure.

Nevertheless, there are open issues:

(1) Risk Assessment is a whole process which consist of a risk estimation (= use of non-inspected PAE), a risk reduction (= inspection) and a residual risk evaluation (= use of an inspected PAE). Only the conduction of the whole process will allow the determination of the added-value and the pertinence of the PAE inspection.

(2) Following the SUD, the Risk Assessment concerns both Human Health and the Environment. Therefore, the risk assessment procedure should be conducted for both compartments separately. The risk for the human health is often totally different than the one for the environment.

(3) The scale of use of the PAE is certainly the most difficult point to define. Several ways can be followed: the number of PAE, the number of hectare threatened by the PAE, the quantity of Pesticides applied by the PAE, the dangerousness of the pesticides applied by the PAE… This issue should be more studied so as to determine the scale of use of the PAE on a common way.

(4) The total risk related to the use of a non-inspected PAE isn’t only causes by technical failures and dysfunctions. The operator is also part of the risk. These different components of the risk should be taken into consideration so as to determine the added-value and the pertinence of the PAE inspection.

(5) From a practical point of view, handheld and small equipment cannot be inspected in the same manner as larger and more complex equipment due to the inspection costs vs price of new equipment (additionally to the low risk).

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Suggestion for an European approach for risk assessment for Pesticide Application Equipment in use to be exempted from inspection according to article 8 (3) of Sustainable Use Directive

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Abstract

Article 8 of Directive 2009/128/EC (Sustainable Use Directive) demands a risk assessment for human health and the environment including an assessment of the scale of use of the equipment in order to apply different time tables and inspection intervals in selected cases for the inspection of pesticide application equipment (PAE) in use or make exemptions from inspection within the Member States. The experts of the SPISE (Standardised Procedure for the Inspection of Sprayers in Europe) Technical Working Group agreed on their meeting in March 2015 to use the Zürich-methodology as an appropriate instrument to implement the demanded risk assessment in a harmonized manner within the EU 28. The article presents the last outcome of the discussions and an approach for risk assessment being applicable on an European level.

Keywords: Directive 2009/128/EC, Sustainable Use Directive, Pesticide Application Equipment, Risk assessment, Inspection of equipment in use, Zürich-methodology

Introduction

Article 8 (3) of Sustainable Use Directive (SUD) provides a risk assessment for human health and the environment including an assessment of the scale of use of the equipment 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.

A still unanswered question is how to exercise this risk assessment in a practical and harmonized manner on European level. For this reason an approach based on Zürich methodology - a risk matrix according to Nohl and Thiemecke (1988) - was elaborated, presented (e.g. Ganzelmeier 2012, Wegener 2014), discussed several times within SPISE community (e.g. SPISE 2014) and SPISE Working Group and enhanced afterwards (e.g. Wegener 2015). The general problem of a common European methodology for risk assessment which needs to be solved is that there is a huge variety concerning the availability and quality of information about numbers and different characteristics of PAE and their utilization amongst the Member States. On this account a common risk assessment procedure being applicable in every single Member State has to be kept as simple as possible concerning data being necessary to implement. As stated in Wegener (2015) there might be other approaches for risk assessment being much more sophisticated compared to Zürich methodology, but this methodology seems to be a good choice balancing necessary input data against informative value of the final outcome.
Material and Methods

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 (Figure 1). Aim of the matrix is to define how high a risk might be. Concerning the risk assessment of PAE in use the advantage of the Zürich methodology is that the risk assessment can be reduced to those technical parameters which are in the focus of the inspection of PAE in use (e.g. Wegener 2014).

![Risk matrix according to Nohl and Thiemecke (1988).](image)

Fig. 1 Risk matrix according to Nohl and Thiemecke (1988).

Wegener (2015) describes the utilization of Zürich methodology for risk assessment of pesticide application equipment in use according to article 8 (3) of Directive 2009/128/EC at the example of Germany. The approach considers eight different groups of PAE:

- handheld sprayers,
- knapsack sprayers,
- hand operated,
- spraying incl. fogging,
- not used for spraying,
- additional/low scale use,
- additional/trains,
- additional/aircraft,
which have been originally defined by Ganzelmeier (2012). In order to generalize this method for other Member States there were still two duties to solve:

- To collect statistical figures about the numbers of PAE within the different groups in the Member States and
- To confirm the qualitative impact of miscellaneous components within different categories of PAE on human health and the environment assessed by Ganzelmeier (2012).

Within an expert survey done by Wehmann (2015a) the numbers of different groups of PAE were collected for ten European countries (Belgium, Czech Republic, Germany, Italy, Luxemburg, Spain, Norway, Sweden, The Netherlands, United Kingdom). Within a second survey experts from nine different European countries (Belgium, Czech Republic, Germany, Italy, Luxemburg, Spain, Norway, Sweden and The Netherlands) judged the impact of different components of PAE on human health and the environment in a qualitative manner (Wehmann 2015b).

**Development of the risk assessment procedure for PAE**

The extent of damage is discharged by a qualitative analyses of equipment components being part of the inspection (acc. ISO 16122) and their impact on human health and the environment in case of technical disorder. Each category of PAE was therefore judged - as stated before - by nine different experts of SPISE by using qualitative measures (++; +; 0; -; --) for the following equipment components:

- Power transmission parts
- Pump
- Agitation
- Spray liquid tank
- Pipes and hoses
- Spray boom
- Filter
- Nozzles
- Controls
- Regulation System
- Distribution / drift
- Cleaning
- Blowers

The qualitative measures were then transformed into a point system: ++ = 20 points, + = 15 points, 0 = 10 points, - = 5 points and -- = 0 points. Afterwards the judgment of each expert was added together for each category of PAE. Table 1 shows the average figures of judgment made by all experts for each category of PAE.
The probability of occurrence is normally figured out by taking the number of incidents of each group of PAE into account (Wegener 2014). Since there are no such statistics available on a national level of all Member States (SPISE 2014) this lack of information has to be solved by taking the number of different PAE in professional use in practice into account, since these numbers should be proportional to the frequency of incidents. For this reason the second expert survey was made to find out about the numbers of PAE in different Member States (Wehmann 2015b). In order to make the reported numbers comparable on a supranational level they were divided by the total sum of arable land per Member State according to national figures (Table 2).

**Tab. 1** Different categories of Pesticide Application Equipment and the proposed impact of their components on human health and the environment (Wehmann, 2015a).

<table>
<thead>
<tr>
<th>Equipment components</th>
<th>Handheld sprayers</th>
<th>Knapsack sprayers</th>
<th>Not used for spraying</th>
<th>Additional/low scale use</th>
<th>Hand operated</th>
<th>Additional/aircraft</th>
<th>Additional/train</th>
<th>Spraying incl. fogging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power transmission</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>15</td>
<td>12</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Pump</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Agitation</td>
<td>10</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Spray liquid tank</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Pipes and hoses</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Spray boom</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Filter</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Nozzles</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Regulation systems</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Distribution/drift</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Cleaning</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Blowers</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Sum</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Priority by sum</td>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
<td>4th</td>
<td>5th</td>
<td>6th</td>
<td>7th</td>
<td>8th</td>
</tr>
</tbody>
</table>

The reported numbers of PAE in professional use sorted by category and accounted per million hectare.

**Tab. 2** Reported numbers of PAE in professional use sorted by category and accounted per million hectare.

<table>
<thead>
<tr>
<th>Member State</th>
<th>Handheld sprayers</th>
<th>Knapsack sprayers</th>
<th>Not used for spraying</th>
<th>Additional/low scale use</th>
<th>Hand operated</th>
<th>Additional/aircraft</th>
<th>Additional/train</th>
<th>Spraying incl. fogging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>22.091</td>
<td>14.728</td>
<td>74</td>
<td>147</td>
<td>2.946</td>
<td>1</td>
<td>16.281</td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>57.405</td>
<td>57.405</td>
<td>287</td>
<td>57</td>
<td>57</td>
<td>9</td>
<td>3.444</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>13.170</td>
<td>23.946</td>
<td>808</td>
<td>299</td>
<td>1.916</td>
<td>0</td>
<td>10.297</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>1.128</td>
<td>2.722</td>
<td>544</td>
<td>389</td>
<td>3.889</td>
<td>1</td>
<td>50.560</td>
<td></td>
</tr>
<tr>
<td>Luxembourg</td>
<td>9.534</td>
<td>22.901</td>
<td>382</td>
<td>1.527</td>
<td>1.527</td>
<td>*</td>
<td>10.053</td>
<td></td>
</tr>
<tr>
<td>The Netherlands</td>
<td>2.671</td>
<td>53.419</td>
<td>1.060</td>
<td>2.671</td>
<td>2.137</td>
<td>1</td>
<td>10.417</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>50.454</td>
<td>10.091</td>
<td>10.091</td>
<td>5.045</td>
<td>3.027</td>
<td>1</td>
<td>20.182</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>2.105</td>
<td>1</td>
<td>*</td>
<td>12.041</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>2.935</td>
<td>24.462</td>
<td>326</td>
<td>294</td>
<td>326</td>
<td>1</td>
<td>5.219</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>2.741</td>
<td>1</td>
<td>1</td>
<td>2.295</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>15.039</td>
<td>21.242</td>
<td>1.358</td>
<td>1.043</td>
<td>1.793</td>
<td>1</td>
<td>14.709</td>
<td></td>
</tr>
</tbody>
</table>

*not reported
In a next step the risk matrix is established by using different levels for the probability of occurrence in a linear scale with an increment of 5,000 PAE per million hectares (Figure 2). Within the first level the sum of the extent of damage for each category (cf. Table 1) is used. The figures within the next lines of the matrix are in each case just the first ones multiplied by the mentioned level. According to Article 8 (3) of Directive 2009/128/EC the categories of PAE being exempted from inspection, if operators are trained, are marked in green, the ones where the inspection is mandatory are marked in red and the ones where different time tables and inspection intervals can be applied are marked in yellow.

![Risk Matrix](image)

**Fig.2 Risk matrix.**

Next the risk tolerance line has to be defined, which is a measure for what kind of risks are still acceptable or not. Therefore, the average numbers of PAE reported in Table 2 (last line) are integrated into the risk matrix in a qualitative manner (Figure 3). To have an equal treatment of all PAE categories considered, the highest acceptable risk is the baseline for the risk tolerance which has to be applied (Wegener 2015). Since the categories “handheld” and “knapsack sprayers” can be exempted from inspection, if the operators are trained, their numbers are basis for the definition of the risk tolerance being acceptable.

**Results**

Figure 3 shows the results following the aforementioned development of the risk matrix. The highest acceptable risk is defined by the number of knapsack sprayers which is within the 5th probability of occurrence level. For this reason the risk tolerance line is at a level of 525. In this case exemptions from time tables and inspection intervals for the three groups of PAE “not used for spraying”, “additional/low scale use” and “hand-operated” can be made.
Fig. 3 Risk matrix including the average figures of PAE per million hectare of ten Member States and the derived risk tolerance line.

Discussion

To apply the risk assessment at Member State level national figures for each category of PAE mentioned have to be integrated in a qualitative manner into the risk matrix presented in Figure 3. This procedure fulfills the aforementioned requirement to be as simple as possible since the quality and availability of national figures are varying strongly. At the end, provided that professional operators are trained, the whole procedure focuses on the categories “not used for spraying”, “additional/low scale use” and “hand-operated”. Even though that the presented risk matrix comes to the result that the categories “additional/aircraft” and “additional/trains are beneath the risk tolerance these cannot be exempted since according to Article 8 (3) of Directive 2009/128/EC they must be inspected anyway!

With respective to the procedure on a national level there are two options. One would be to have one European risk tolerance line derivated from mean values as shown within this paper. This is the option which is preferred by SPISE experts. But, therefore it would be desirable to have more national data than just from the ten Member States presented here. Another option would be that every Member State derivates its own risk tolerance line only based on national figures as shown in this paper and uses this to judge about the possibilities to make exemptions.

Literature


Article 8 of Directive 2009/128/EC (Sustainable Use Directive) demands a risk assessment for human health and the environment including an assessment of the scale of use of the equipment in order to apply different time tables and inspection intervals in selected cases for the inspection of pesticide application equipment (PAE) in use or make exemptions from inspection within the Member States. The experts of the SPISE (Standardised Procedure for the Inspection of Sprayers in Europe) Technical Working Group agreed on their meeting in March 2015 to use the Zürich-methodology as an appropriate instrument to implement the demanded risk assessment in a harmonized manner within the EU 28. The article presents the last outcome of the discussions and an approach for risk assessment being applicable on an European level.
The Belgian approach to fulfill art 8 of directive 2009/128: Development of a risk assessment procedure for pesticide application equipment

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Summary

The EU Directive 2009/128/EC on the sustainable use of pesticides requires that Member States (MS) shall ensure that all Pesticide Application Equipment (PAE) in professional use shall be subject to inspection at regular intervals. Article 8.3 of the Directive allows the MS to derogate from the mandatory inspection at regular intervals or to apply different timetables and inspection intervals for certain types of PAE based on a Risk Assessment (RA) for human health, food safety and environment and an assessment of the scale of use.

In Belgium, a risk assessment protocol is being developed within the framework of the SIRA-APESTICON project. It will be applied on the equipment in use and will offer guidelines about the necessity to carry out an inspection of every PAE in use. Risk will be evaluated for the health of the operator, for the health of the consumer and for the environment. The protocol is supported by a literature review and by experts’ opinion. It is based, among others, on technical parameters subject to inspections and on scale of use of the PAE types. Description of the risk assessment method and first results will be presented at the SPISE workshop.

Keywords: pesticide application equipment, inspection, risk assessment, protocol, inventory, exemption, intervals, scale of use.

Introduction

The EU Directive 2009/128/EC on the sustainable use of pesticides requires that Member States (MS) shall ensure that all Pesticide Application Equipment (PAE) in professional use shall be subject to inspection at regular intervals (Article 8.1 and 8.2).

The inspection of the material requested by the Directive concerns all types of PAE for all types of pesticides formulations (liquid, solid, gas, etc.) without any distinction. However, Article 8.3 of the Directive allows the Member States to derogate from the mandatory inspection at regular intervals or to apply different timetables and inspection intervals for certain types of PAE based on a Risk Assessment (RA) for human health and environment and an assessment of Scale of Use. MS have to provide a list of PAE subject to exemption. The Risk Assessment process should demonstrate the usefulness of the inspection to significantly decrease the risk of the use of the PAE. The SPISE Technical Working Group 2 (Spise TWG 2) developed a first protocol based on the Zurich method (Wegener, 2015). For the moment no standardized protocol of Risk Assessment is available in what concerns the risk decrease after PAE technical inspection for PAE types potentially concerned by the derogation.

A preliminary EU enquiry has been realized with the representatives of the sprayer inspection in all the MS of the SPISE Community. With 19 responses, the results from the enquiry show a large variation in the inspection situation of the different PAE types over
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Barcelona, Spain, September 13 – 15, 2016

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In Belgium, a project called SIRA-APESTICON, started in 2015, aims at developing a scientific solution to these issues. Among others, objectives are to develop and validate a RA protocol and apply the RA protocol on the PAE in use in Belgium. Results should help to provide a list of PAE subject to exemption based on Risk Assessment (human health and environment).

Material and methods

The RA protocol was developed on basis of literature review and expert opinions. Most RA published in the literature were elaborated in order to fit with case studies (Bach M. R.-G., 2005; Choi H. M.-K.-H., 2013; Reus J. L., 2002; Roussel O. C., 2000). So, for this work, the protocol has been adapted thanks to pragmatism, experts’ judgment, and by taking into account available data.

First, with literature content, concept of RA has been defined. Risk factors, context and limitations of the RA were subject of discussion and debates before to be determined. All data available were gathered. All parts of the RA (list of defects, list of harm situation, calculation of occurrences, calculation of scale of use, etc.) were progressively readapted to the context and the limitations during the method development.

Results and discussion

Inventories: PAE types, inspection protocols and test equipment protocols

Types of PAE used in Belgium have been inventoried based on a review of the literature, an internet search and a national enquiry with 366 responses. In total, 29 PAE types have been defined and described:

- Field crop sprayers and similar
- Sprayers for bush and tree crops
- Sprayers for vineyards
- Fixed and semi mobile sprayers
- Knapsack sprayers
- Spray train
- Lances and spray guns
- Handheld sprayers
- Rotary atomizers or CDA (Controlled Droplet Application) sprayers
- Cold atomizers
- Soil disinfection equipment
- Plot sprayers
- Irrigating systems where pesticides are dosed to the plants by drippers
- Irrigating systems where pesticides are dosed to the plants by the sprinkler system
- Weed wipers
- Handheld weed wipers
- Potato seed duster
- Seed treatment machinery
- Granule spreaders
- Seeders (not considered as PAE by European Commission)
- Sulphur evaporator
- Tree trunk implantation/injection
- Tree painting
- Post harvest treatment system
- Post harvest ripening systems using ethylene
- Aerial spraying

Concept of Risk assessment

The first step to develop a RA protocol is to define what the risk is. RA’s methodologies generally are so adapted to case studies that there are as many protocols as case studies. Nevertheless, a lot of authors agree on the main concept: Risk is a combination of a

More information: Inventory of pesticide application equipment used in Belgium – a practical approach (Nuyttens, Zwetvaegher, Declercq, Mostade, Stas, Defays, Dekeyser, Huyghebaert). Session 2, SPISE meeting 2016.
hazard, an exposure and a probability of occurrence. For example, FAO (2015), the IPCS (2010) and other authors (Cox J., 2009; Johansen I., 2010; Touche D.a., 2012) and in the ISO 31000 (2009) provides principles and generic guidelines for a lot of Risk managements and assessment. In the context of this work, several methods of RA evaluation have been raised from publications as interesting sources of information. They include PRIBEL index (Vergucht S.C., 2006), Fuzzy Expert System (Roussel O.C., 2000; van der Werf H.Z., 1998; Zhang Y.Z., 2013), Zurich methodology (Ganzelmeier H., 2012; Wegener J., 2013; Wegener J., 2015), the classification of Parkin et al. (Parkin, 1994), Risk index of Spugnoli et al. (Spugnoli, 1998), and the EOS tool (Doruchowski, 2014). Some specific points have been retained from the different methods for the development of the RA protocol within this study. For instance, the matrix concept of the Zurich methodology is useful to associate the scale of use and hazard exposure; experts’ opinion from the fuzzy logic application is appropriate to define the severity of harm and the human behavior part of risk…

A risk depends of the severity of harm resulting from the hazard on the exposed subject, and on the probability of occurrence of that harm. Then to develop the risk assessment, some questions have been precisely answered: What is/are the hazard situation(s); who/what is concerned by the hazard situation(s) and which harms have to be taken into consideration.

In the framework of the project, the risk related to the use of a PAE is based on the technical dysfunctions or technical defects of this PAE, occurring during the pesticides application. Thereby, for every type of PAE, risks to human health and to environment are evaluated. Risk should be evaluated as well at the scale of one machine as at national (Belgian) scale. In both situations, it has to be evaluated “before inspection” and “after inspection”. Between the “before” and the “after inspection”, a diminution of risk should be observed. This diminution could justify the necessity to inspection. The whole process evaluation of the risk “before” and “after inspection” constitutes the complete RA of a given PAE type.

**Hazard definition**

In this project, it is considered that the hazard is only related to the technical dysfunctions, or defects of the PAE. It is limited to the use of the PAE: preparation of the equipment, pesticide application and cleaning of the equipment. One assumes that applied pesticide toxicity is an invariable factor. Indeed, a given PAE can apply different pesticides (active ingredients) presenting each different levels of hazard. Therefore, it is nearly impossible to determine the hazard presented by the use of a PAE taking into account the pesticides/active ingredients and their related toxicity. Moreover, because of their independence from the technical aspects, the local external conditions (as wheater, cultural practices, human behavior…) are considered also as invariable. Therefore, one assumed that PAE are used following the Good Agricultural Practices.

All defects/dysfunctions of a single machine allow calculating the technical risk for this entire and single machine by the way of the severity of harm.

**Severity of harm**

In theory, harm is the consequence of the hazard on the exposed subject. In the context of this project, it is the consequence of technical defects on human health and environment: over-dosage, under-dosage, or injuries induced by the use of PAE during the pesticide applications. Severities of harm need to be evaluated to estimate the risk. In order to do it,
A questionnaire has been submitted to experts’ judgment. Severities of harm are evaluated for every inspected parameter, in the situation of defect “before inspection” and in the situation of repaired defect “after inspection”. The severity is defined as a relative value between 0 and 10 (10 being the most severe harm). It should be noticed that it is absolutely possible that the severity of harm of a defect after inspection (reparation) can be different than 0. Even after reparation, an inspected parameter can present a residual hazard.

Nature and severity of harm are different regarding the exposed subject (operator, consumer and environment). For this reason, there are different evaluations for each of these three subjects.

**Dysfunctions/defects table**

In practice, the defects correspond to the parameters that are inspected. Since the consequences of the defects are the basis of the hazard definition, then a list of the parameters, consequences and extent of consequences has been elaborated. Inspected parameters are sometimes described with tolerance levels. Consequences are descriptions of the harm on environment and on human health. Extents are evaluations of the surface impacted. They can be one isolated place, a strip or a global contamination (e.g.: the whole parcel treated). Parameter, consequence and extent descriptions help to determine the severity of harm from a defect.

**Occurrence**

In the context of PAE inspection, probabilities are the occurrences of technical defects. They are defined for each inspected parameter due to the available data from the Belgian sprayer inspections (Field crop sprayers, Orchards, Fixed and semi mobile sprayers). They are calculated from last complete cycle of inspection (the three years 2011, 2012 and 2013) and are expressed in percentage. Occurrence is combined with the severity of harm of each defect in order to calculate a risk, at the level of a single machine.

**Scale of use**

Scale of use should reflect the amount of utilization of a specific type of PAE at Belgian scale. It would be estimated on basis of amount of pesticides applied by each group of PAE (Vergucht et al. (2006) did it a little differently for the “PRIBEL index”) and on basis of the number of PAE (as done in the Zurich methodology (Wegener, 2015)).

In this work, the scale of use is based on 3 factors:

- Amount of pesticides sold in Belgium each year. National data are available. In the same way as for occurrences, the scale of use is calculated on the last complete inspection cycle.
- Repartition of active substances potentially used among PAE types. This repartition was realized by experts specialized in pesticides and in PAE inspection.
- Frequency of use of each PAE type. A national enquiry allowed evaluating the number and frequencies of use of the PAE types in Belgium. It was conducted with professionals and Flemish farmers. 42 professional and more than 300 farmers answered.
Thereby, the number of machines in use in Belgium and the amount of pesticide potentially applied by this type of PAE on Belgian territory are taken into account in the risk evaluation. Results of scale of use are expressed by relative values.

Subjects exposed

The human health and the environment are exposed to hazard situations. In this work, the operator, the consumer and the environment are considered as exposed subjects. All compartments of the environment (soil, water, air, wildlife...) were gathered together because expert opinions about severities of harm don’t vary enough between these compartments. On the other hand, the operator and the consumer are distinguished. Indeed, the ways of exposure (then the severity of harm) and the scales of use are very different. The bystander will not be part of the RA calculation. Indeed, inspection does not look at equipment components that specifically concern risk to bystander. Moreover, variations of risk due to external conditions like weather or operator behavior are too big compared to the inspection impact on the bystander.

The three subjects exposed are taken into account in the whole risk assessment from the evaluation of severity of harm.

Partition technical part of risk vs human part of risk

This project focuses on technical sources of hazard. Indeed, pesticide application becomes more dangerous with occurrence of PAE technical defects. However, another source can cause an imperfection on the application: human mistake (or human behavior). Therefore one considered that total risk of suboptimal application is divided into a technical part and a human part.

In order to determine the size of each part, an enquiry was launched with experts. Human and technical parts were determined for every PAE type. Results are expressed by a percentage on the total risk relative to the suboptimal pesticide application.

Risk assessment calculation

Risk is calculated by the way of some steps (Figure 1). First, severity of harm of a defect is combined with the probability of occurrence of the defect. Second, results from all defects are added to evaluate a global risk of one single and entire machine. Third, the risk related to one machine is extrapolated at the concerned PAE type in Belgian territory thanks to a national scale of use. Finally, in case of relevance, the risk relative to technical part of the equipment can be compared to a global risk of pesticide application, also concerned by human behavior. All calculations are made once with data of “before inspection” and once with data of “after inspection”. Thereby, risk related to pesticide application “before inspection” can be compared to risk related to pesticide application “after inspection” and a risk reduction can be observed.
Conclusion

The method focuses on PAE types that potentially are concerned by derogation from the EU Directive 2009/128/EC requirements. Flexible, it could be improved by the future increasing knowledge about these PAE types, not yet inspected and not much studied until now. To our knowledge, this method is the first RA method that considers a maximum of available parameters involved, in the context of PAE technical inspection. Occurrences are representatives of the reality of inspection, as they are defined with data of the country studied. Judgment by experts from different disciplines offers also a more complete analysis of the risk.

According to the Directive requirements, some PAE types will soon be inspected for the first time. For them and for PAE types already inspected, new inspection protocols adapted to the risk are needed. Results of risk variation between all defects, results of the scales of use, literature and expert knowledge should help to elaborate these future protocols.

The complete RA including the scale of use study can serve as decision support tool to apply Article 8.3 of the Directive 2009/128/EC. In particular, the risk reduction from “before” to “after” inspection should help in the decision about mandatory inspection and about inspection intervals.

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Inventory of pesticide application equipment used in Belgium - a practical approach.

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Summary

The EU Directive 2009/128/EC on the sustainable use of pesticides requires that Member States (MS) shall ensure that all Pesticide Application Equipment (PAE) in professional use shall be subject to inspections at regular intervals. However, Article 8.3 of the Directive allows the MS to derogate from the mandatory inspection at regular intervals or to apply different timetables and inspection intervals for certain types of PAE based on a Risk Assessment (RA) for human health, food safety and environment and an assessment of the scale of use. This paper presents an inventory of the different types of PAE used in Belgium and an estimation of their scale of use. The work was done within the framework of the SIRA-APESTICON project, aiming at the development of a RA for PAE in Belgium.

In total, 29 PAE types have been identified and described in detail based on a review of literature, an internet search and a national enquiry with 366 responses from farmers and professional contacts. Based on this enquiry and in order to define their scale of use, the number of machines in use as well as the estimated amount of pesticides applied were determined for each type of PAE. The inventory focused on PAE types which are currently not yet inspected in Belgium.

Keywords: pesticide application equipment, inventory, risk assessment

Introduction

The EU Directive 2009/128/EC on the sustainable use of pesticides requires that Member States (MS) ensure that all Pesticide Application Equipment (PAE) in professional use are subject to inspections at regular intervals (Article 8.1 and 8.2). In this context, pesticides are defined as plant protection products and do not include biocides, veterinary medicines, etc. The inspection of the material requested by the Directive concerns all types of PAE for all types of pesticides formulations (liquid, solid, gas, etc.) without any distinction.

However, Article 8.3 of the Directive allows the MS to derogate from the mandatory inspection at regular intervals or to apply different timetables and inspection intervals for certain types of PAE based on a Risk Assessment for human health, food safety and environment and an assessment of scale of use.

At this moment, Belgium has developed an inspection scheme for four types of PAE (field crop sprayers, orchard and vineyard sprayers, spray booms used in greenhouses and soil disinfection equipment), while other types of PAE are not yet considered (foggers, hand-held sprayers, spray lances, granule spreaders, seed treatment machinery, etc.).

Considering the Directive’s requirements, Belgium (and the other MS) has, by the end of 2016, to inspect at least once all other types of PAE or has to present a list of PAE which could derogate from the mandatory inspection. The derogation must be based on a Risk
Assessment process demonstrating the usefulness of the inspection to significantly decrease the risk of the use of these PAE.

The problem is that for the moment no standardized inspection protocols or Risk Assessment procedures are available for the other types of PAE, making it impossible for the MS to demand for an exemption. For that reason, a research program, called SIRA-APESTICON, was started aiming at the development of this RA for PAE in Belgium and finally to answer to the EU Directive 2009/128/EC requirements. Objectives are to develop and validate a RA protocol, to apply the RA protocol on the PAE in use in Belgium, and to develop inspection protocols according to the RA protocol for the PAE in use, which are not subject to exemption and not subject to inspection at the moment.

**Tab. 1 Overview of the 29 PAE types and their status in Belgium according to the EU directive**

As a first step in this project, the different types of PAE used in Belgium have been inventoried and classified. In order to define their scale of use, the number of machines in use as well as the estimated amount of pesticides applied were determined. The inventory
focused on PAE types which are currently not yet inspected in Belgium, among others, PAE not used for spraying pesticides, handheld PAE and knapsack sprayers, and additional PAE that represent a very low scale of use.

**Classification of PAE machinery**

Based on a review of the literature, a provisional inventory of the existing PAE used in Belgium was made. In total, 29 PAE types were defined. An overview of the different PAE types is given in Table 1, along with the status in Belgium of every PAE according to EU Directive 2009/128/EC, categorized as follows:

- PAE types already inspected in Belgium.
- PAE types that have to be inspected in Belgium based on Belgian legislation.
- PAE types for which different timetables and inspection intervals might be applied based on Article 8.3a from EU Directive 2009/128/EC, i.e. PAE not used for spraying and PAE that represent a very low scale of use.
- PAE types for which exemption from inspection is possible based on Article 8.3b from EU Directive 2009/128/EC, i.e. handheld PAE or knapsack sprayers.
- PAE types forbidden in Belgium.

Type 23, i.e. seeders, are often used to apply pesticide coated seed, and were originally also included in the list of PAE types. After consultation of the European Commission, it became clear that seeders should not be considered as PAE and therefore are not subject to the EU Directive 2009/128/EC.

**Enquiry on PAE machinery in Belgium**

An enquiry aiming to obtain more detailed information on the number of PAE in use and the applied amount of pesticides per PAE type was sent to 406 professional contacts in Belgium (304 Dutch & 102 French speaking) and 1536 Flemish farmers. Contacted farmers originated from the database of the Flemish sprayer inspection. This means that these farmers have (at least) one PAE device that is already inspected, and therefore this group of farmers might not fully represent the professional users of PAE in Belgium. The focus of the enquiry was on the PAE types 1 to 23, as the other categories were considered to be very low scale of use in Belgium.

Depending on their category, professional contacts received different questions, such as:

- Could you estimate the total number of devices per PAE type that are used in Belgium for professional use?
- Could you estimate the percentage of pesticides used per type of PAE?
- Do you know any other types of PAE that were not in the list? Can you give additional information about one or more of the PAE types?
- Farmers were asked to give information about:
  - The number of devices they own per type of PAE.
  - An estimation of the amount of pesticides they use per type of PAE as a portion of their total pesticide use.

In total, 29, 13 and 324 responses were registered for Dutch speaking professionals, French speaking professionals and Flemish farmers, respectively. This corresponds to a response
of 10% for professional contacts and 21% for farmers. Professional contacts were divided into categories depending on their activities and expertise. Figure 1 shows the number of professional respondents per category. Results of Dutch and French speaking contacts were merged for the enquiry analysis.

**Fig. 1 Number of professional respondents per category**

**Number of PAE in Belgium for professional use**

![Diagram showing the number of PAE in Belgium per type of PAE](image)

**Fig. 2 Estimation of the number of devices in Belgium per type of PAE. Green values are based on numbers in the database of the sprayer inspection, orange values are based on estimations by 23 professional respondents.**
In Figure 2, an estimation of the total number of PAE in Belgium per type is presented. For the categories ‘field sprayer’, ‘orchard sprayer’, ‘vineyard sprayer’, ‘fixed and semi-mobile sprayers’ and ‘spray train’, the amount of devices is based on the number of (already) inspected machines in Belgium. For the other types of PAE, the numbers are based on the enquiries of 23 professional respondents.

Besides the already inspected types, high numbers were estimated for the knapsack sprayers (> 21000 devices), seeders, handheld sprayers, spray lances and granule spreaders. Other PAE types were estimated to have a much lower scale of use (< 1000 devices).

Recently, the inspection of soil disinfection equipment was started up in Belgium. Already 17 machines are inspected. From the enquiry, a much higher amount of devices is reported. This could mean that some of the devices are not yet registered by the sprayer inspection service, or this figure was overestimated by the respondents.

The reported “other types” could be categorized under PAE types 24 up to 29. No new PAE types were mentioned in the enquiries.

The farmers were also enquired about the number of PAE they use on their own farm. Figure 3 reports the average number of devices per type of PAE, expressed per 100 farmers. The responses indicated that some of the farmers have more than one device per type of PAE. Therefore, Figure 4 shows the proportion of farmers owning one, two or more devices.

![Fig.3](image)

**Fig.3 Average number of devices per type of PAE, expressed per 100 farmers, based on the responses of 324 Flemish farmers**
For reasons of comparison between the results of the professionals and the farmers, the number of each PAE type was expressed as a portion of the total estimated number of PAE devices in Belgium, or the total number of devices per 100 farmers respectively (Figure 5).

The same trend was seen for the PAE owned by the farmers and the estimations made by the professionals. Besides the already inspected PAE, knapsack sprayers are very common on the farms. More than 80% of the farmers owns at least 1 knapsack sprayer, 20% has more than one.

**Pesticide use per type of PAE in Belgium for professional use**

The farmers were asked to make a division of their pesticide use per type of PAE as a portion of their total pesticide use. Professional contacts were asked to make a similar division for the total pesticide use in Belgium. Comparison of both results is shown in Figure 6.

A good correlation was found between the estimations of the professionals and the responses of the farmers. From the results, it is shown that more than 85% of the estimated pesticide use in Belgium is applied with PAE that are already inspected.

For the spray train, an estimation of 3.69% of the total pesticide use in Belgium was made. Although there is only one spray train in Belgium, it applies a huge amount of the total pesticide used in our country. This shows that the pesticide use per type of PAE is relative, and should also be calculated per single device to have a better comparison.

**Fig.4 Number of devices owned by a single farmer**
In order to estimate the pesticide use per single device, the pesticide use per PAE type (Figure 6, results enquiry professionals) was divided by the estimated number of devices in Belgium (Figure 2). The results are shown in Figure 7, sorted from a high to a low pesticide use per device.

**Fig.5** Portion of each PAE type in the total estimated number of PAE devices in Belgium. Orange values are based on the estimation by 23 professional respondents, completed with the green values based on numbers in the database of the sprayer inspection. Blue values are based on the enquiries of 324 Flemish farmers.
Fig. 6 Pesticide use per type of PAE as a portion of the total estimated use of pesticides in Belgium. Orange values are based on the estimation by 9 professional respondents, blue values are based on het enquiries of 298 Flemish farmers.
**Fig. 7** Pesticide use per single device based on the number of PAE and the pesticide use estimated by the professional contact. Types of PAE are sorted from high to low pesticide use. Note the logarithmic scale of the X-axis.

**Conclusions**

From a literature review, 29 types of pesticide application equipment were defined, including seeders, which should in fact not have been considered as a PAE. The scale of use of the different PAE types was estimated from figures of 324 farmers and 42 professional contacts that responded to a national enquiry.

Results showed that, next to the PAE categories that are already inspected, knapsack sprayers, handheld sprayers, spray lances and granule spreaders are the most common PAE types that are not yet inspected. More than 85% of the pesticide use is applied with PAE types that are already under inspection in Belgium.

Results of this inventory will be further used in the development of a Risk Analysis for the different types of PAE, in fulfillment of the EU Directive, and to consider the possibility to derogate from the mandatory inspection.

**References**

Session 3

Sprayer inspection harmonised test methods

The importance of a harmonized application of EN-ISO 16122: The SPISE manual

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SPISE TWG 3 was created after SPISE Workshop n°4 in 2012 (Lana, Italy) and aims at developing harmonized test methods for sprayer inspection. In between the publication of EN-ISO 16122 series 1-2-3 in 2015 was then a foundation for a harmonized sprayer inspection in Europe. The part 1 describes the general requirements, the part 2 focuses on the testing of horizontal boom sprayers and part 3 focuses on the testing of bush and tree crop sprayers. Those standards describe the mandatory or optional outcomes but, in general, the testing methodologies are left open to different options. A SPISE manual for sprayer inspection was then developed in order to provide useful information on how to achieve the test and the evaluation of the outcome of the measurements.

This document reflects the structure of the above mentioned normative bases with general requirements, the testing of horizontal boom sprayers and the testing of bush and tree crop sprayers.

This document was circulated among the Spise working group during fall 2015 for feedback. The document was very well evaluated with numbers of pictures describing good and bad examples from practical situations. This document is then an excellent basis for sprayer inspector training.

However this document also raises the issue of copyright while a number of original text from EN-ISO standards are explicitly quoted. A discussion with ISO TC23 SC6 secretary was initiated in order to define the status of documents elaborated for a practical implementation of EN and/or ISO standards.

Future work of the TWG will then focus on the possibility to unlock all the obstacles prior the dissemination of the SPISE inspection manual.

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Introduction

As a result of the acceptance by CEN of the mandate from the European Commission standards for all kinds of PAE has to be developed. In Europe are the sprayers used in greenhouses, next to the field-crop sprayers and air-assisted sprayers for bush and tree crops, an important group of machines. Therefore within CEN TC144 WG3 standards are developed for this equipment in this category, both for new machines and machines in use. The title of this group of machines, what should cover this wide range of sprayers, is: ‘Fixed and semi-mobile sprayers’. This work was finished with the publication of EN-ISO16119:4 (for new sprayers) in 2014 and EN-ISO16122:4 (for testing sprayers in use) in 2015.

Equipment covered

The range of equipment covered by this standards are very wide. The limitation is that this standards are intended for high-volume application equipment. Low-volume spatial application equipment like Fog and LVM equipment are not covered.

This equipment is mostly used in greenhouses but can also be used outside, for example in tree-nurseries. The similarity of the equipment covered, is that machines exist of a pump/tank unit and one of more separate application unit(s). The pump/tank unit can be fixed mounted or be semi-mobile to be moved in the greenhouse. The application units can be:

- A spray-gun or spray-lance
- A vertical spray-boom
- A horizontal spray-boom

The complete machine (installation) exists of:

- Pump/tank unit (fixed or semi-mobile):

![Figure 1 Fixed pump/tank unit](image1)
![Figure 2 Semi-mobile pump/tank unit](image2)
- Transport-means to transport the liquid from the pump/tank unit to the application unit:

![Figure 3 Reel for transport spray-liquid](image)

- Application unit

![Figure 4 Spray-gun and ‐lance](image)
![Figure 5 Horizontal spray-boom](image)
![Figure 6 Vertical spray-boom](image)

**Specific differences with part 2 and 3**
The general principles of the standard EN-ISO 16122:4 are the same as for the part 2 and 3. However due to the specific circumstances and operating conditions this type of sprayers, there are some differences:

- 2. and 3. Pump and agitation

  Regarding the requirements for the capacity of the spray-pump and the evaluation of the agitation, there is a difference for machine produced before the standard EN-ISO 16119:4 was published and the older machines. For the older machines, the same requirements as in part 2 and 3 apply, for the younger machines, based on EN-ISO16119:4, the manufacturer shall specify the flow needed for a proper agitation of the spray-liquid tank. So the flow-rate (in l/min) of the spray-pump, shall be this minimum needed agitation flow + the flow-rate needed to spray.

- Spray liquid tank

  A lid shall always be present, also for fixed installations, only for semi-mobile machine this lid shall be tightly sealed.

  A strainer in the filling hole is only required for semi-mobile machines.

- Measurement systems, controls and regulation systems

  A manometer shall always be present on the pump/tank unit, the purpose of this manometer is to control the pressure of the pump. Also on the application-unit a manometer shall be present to control the spray-pressure, only on spray-guns a manometer is not required.
In this chapter also requirements for a dosing-unit which doses the pesticides, are added. The requirement of this dosing unit are:

i. no leakage of both water or pesticides
ii. no back-flow of both water or pesticides
iii. a mixing chamber shall be present
iv. a setting shall be accurate, a method of verification is included in the standard.

• Filters
On the pump/tank unit shall be a suction filter present (in case of a positive displacement pump).
On the application unit, a pressure filter shall be present, except for spray-guns/lances.

• Application unit(s)
  i. horizontal spray-booms
     Same requirements as in part 2.
  ii. vertical spray-booms
     Same requirements as in part 3.
  iii. spray-guns/-lances
     Same requirements as in part 2 and 3.

• Distribution
Evaluation of the distribution equal as in part 2 and 3, only the evaluation of the horizontal cross-distribution is optional.

• Autonomous application systems
  i. the drive system of the unit shall be in good condition, no excessive wear of the parts of the drive system
  ii. the travel speed shall not deviate more than +/-10% as declared by the manufacturer.

Problems and challenges for the future
This standard EN-ISO16122:4 is the accumulation of the knowledge and experience of the members of WG3 of CEN at the time of the development of the standard, however when working now with this standards on a larger scale in practice, there are some issues what are not clearly solved in this version of the standard.

Some of this issues are:

• How to deal with monorail installations with a horizontal sprayboom?
• How to deal with complete sprayers?
• Some requirements in the standards are not very clear:
  i. The requirements for the evaluation of the pump and agitation for older installations
  ii. The presence of the lid/cover on fixed installations
  iii. The emptying of the tank for fixed installations
iv. The readability of the content of the spray-tank, from the outside or from the inside?

v. The requirements for pressure indicators, requirements for the scale for higher pressures are missing and not clear if a manometer must meet the requirements of accuracy over the whole range of pressure.

vi. The requirement of the possibility of cleaning and control possibilities for suction filters.

vii. The measurement of the driving speed for motorized application units.

What is missing is this version of the standard are beside the already mentioned requirements for the scale for manometers for higher pressures, requirements for a reel, for hand-operated, spring-operated and motorized operated reels. Items about safety, rolling speed, control possibilities, etc. should mentioned.

This item will be dealt with during the next revision of this standard.

Conclusion

Beside the before mentioned reservations, this standard EN-ISO 16122:4(2015) is a good base to start the inspection of both fixed and semi-mobile spraying installations currently in use. Based on the experiences gained in the different member-states, within WG3 we can improve the standard during the next revision.

References


Possibilities to inspect seed treatment equipment

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Summary
The inspection of sprayer in use in all EU Member states (MS) became mandatory with the European Directive 2009/128/CE. In Germany the inspection for seed treatment equipment must be introduced before the end of the year 2020. For the moment we don’t have any standards neither for brand new seed treatment equipment nor for equipment in use. The range for machines for the seed treatment are wide and inhomogeneous: From machines in laboratory with 50 g seed up to industrial systems with capacity of more than 30 t/h. The equipment can be located on farms or on the field (mobile), at contractors or warehouses. Often it is not clear if a mobile equipment, for example on potato planting machines, belongs to the group of seed treatment machine or not – in Germany such an equipment where inspected as a sprayer for field or row crops. To set up requirements for inspection of seed treatment equipment in use, special mobile inspection staff and a guideline for the inspection procedures is needed. It is proposed to address these issues in a SPISE Advice paper. As a basis for further discussions some requirements regarding safety, filling, dust collection, dosage, cleaning, fittings, pipes and hoses and filtering are presented in this paper.

Keywords: seed treatment, inspection, SPISE.

Introduction
The inspection of sprayers in use in all EU Member States (MS) became mandatory with the official publication in November 2009 of the European Directive 2009/128/CE. Since 2009, each member state has established a mandatory Inspection for sprayers. Certain devices can be exempted from the inspection procedure, for other equipment transition periods have been determined up to which an inspection must have taken place. In Germany for seed treatment equipment this period ends in the year 2020. It is time to analyze the possibilities of the inspection of seed treatment equipment units closer.

Actual situation
At present, no standards are available for brand new equipment or for equipment in use.

Fig. 1-2 (JKI and Eskil Nilsson): Stationary picking unit for large quantities of seeds (above). Laboratory equipment for small batches of seed (right).
CEN has already announced not to draw up new standards for seed treatment equipment. In Germany a guideline with requirements for new equipment for a voluntary JKI-Approval of seed treatment equipment, exist. These requirements are the same as those valid until 2011 in the declaration procedure in Germany. The equipment for seed treatment is very inhomogeneous: There are mobile and stationary equipment, equipment for laboratory use with 50 g - samples up to industrial systems with more than 30 t / h capacity. Machines ranges from equipment on farms with an annual output of few tons to large systems with several thousand tons.

**Definition of seed treatment equipment**

Equipment for seed treatment may be constructed very differently. Both mobile (rarely) as well as stationary devices (mostly) are in use. The transitions between sprayers for field crops or row crops and mobile pickling units are not very sharp. So the additional equipment on potato planting equipment is often referred as a pickling unit but can also be defined as a band-sprayer for row crops. In Germany, the described devices will be counted to sprayers for field crops and should be inspected already. For the inspection procedure for seed treatment equipment in Europe, we need additional requirements for these devices, training of control staff and a definition which devices are affected precisely under “seed treatment“ which must be inspected until the end of 2020.

**How to inspect seed treatment equipment**

For the inspection of stationary operated pickling units, first new inspection staff must be available and trained for the special situations in seed treatment. Because the inspection must take place on the company ground, on farms or at contractors, the stuff must be willing to travel. Requirements for seed treatment equipment in use must be worked out as well as a guideline for inspection procedures and for staff. It is proposed to address these issues in a SPISE Advice paper.
Especially the dosage accuracy, the tightness of the equipment, the safety and the accuracy of the used measuring instruments must be checked during the inspection. This can take place usually only under normal operation of the equipment, as well as cereal and Chemicals (PPP) must be present for a trial run during inspection. The inspection process is therefore only possible in certain seasons.

The established certification system in Germany for dust-free seeds investigated as part of the certification process also pickling units. It became clear that the calibration of the equipment must be regularly checked and documented by the user. The adjustment of the dosage has to be checked by the user for each new batch of seed. The check of these documents during the inspection would be a good idea, so that further analysis of the
dosage could be omitted thereby. In the certification process leakages at pickling units, especially when the location for the reservoir of PPP and pickling unit going over several floors, were commonly observed as well as not or poorly cleaned devices with encrustations that complicate proper operation of the machine. This makes the inspection of the device for the control staff difficult and may cause health problems when handling PPP. During the inspection the use of PPP should be avoided instead of water. But not all PPP based on the basis of water, so that inconclusive results are produced. Special equipment as those for the production of beet seeds or rape seed could not be assessed on the basis of water. The inspection of the dose rates on the basis of water with those machines is not practical.

Requirements for seed treatment machines as a basic for further discussions

The following requirements are intended to serve as a basis for further discussion and can be seen as a suggestion. They are based on the previous requirements for new machines in the German declaration process which were valid until the end of 2011, the present requirements in the JKI approval process and some requirements in the standards for inspection of sprayers in use - EN ISO 16122.

1. Safety
   1.1 Drive elements such as drive shaft, chain, sprockets, belts, gears, etc. need to be checked. The protection of drive shafts must be suitable and in good condition. The individual parts of the shaft, the joints and locking devices shall have no evidence of excessive attrition and must function properly. Protective devices must be provided and shall have no evidence of attrition, holes, deformations or cracks. The protective devices and rotating power transmission parts shall not be impaired in their function. For equipment with electric drive, make sure that the electrical connections (connectors, cables) are free of bruises, cracks, deformations or exposed wires. Minor defects: Minor attrition of drive elements, inadequate lubrication of the chain, belt slightly damaged, to low belt tension.

2. Seed treatment
   2.1 Continuously operating devices: A storage container (perhaps optionally) must be large enough to allow at least one hour in work without refilling.
   2.2 It must be possible to calibrate the seed treatment equipment. For calibrating of the seed treatment equipment it shall be possible to collect the seeds and the Chemical (PPP) at the outlet separately before the pickling process has been started.
   2.3 Continuously operating devices: When the seed flow is stopped, the PPP-flow must be interrupted automatically.
   2.4 Continuously operating devices: When PPP-flow stopped, also the seed stream must be interrupted automatically.
   2.5 Seed treatment equipment must have a possibility of adjusting the volume weight of the seed lot.
2.6. Hoses, lines and pumps for PPP must be free from leaks.
2.7. Continuously operating devices must be equipped with means for removing dust.
2.8. Explanation: A connection for a dust extraction system is sufficient if an appropriate extraction unit can be connected at the place where the equipment is installed.

3. **Filling and PPP-Containers**

3.1. (For liquid containers that are not pressurized, the filling opening must have a diameter of at least 100 mm.) = Constructive specification coming from the requirements for new machines!
3.2. (The filling of containers for dry formulated PPP must have a clear width of at least 200 mm.) = Constructive specification coming from the requirements for new machines!
3.3. While filling appropriately no PPP shall be splashing back.
3.4. The container lid shall be and free of deformations and holes. Cover seals shall be present and not damaged.
3.5. The level of liquid inside of the provided container or mixing tank must be determined by a scale. Explanation: This may be possible also by an inner scale.
3.6. Agitation: There must be a good visible agitation of the mixing system in operation with a half-filled container.

Explanation: It is important to ensure proper installation of the agitator.
Note: This is about the agitation of the original PPP = acceptable?

3.7. A pressure-compensation must be ensured (to avoid over- or under-pressure in the tank).

4. **Dust collection**

4.1. Means for removal of dust must be designed in such a way that no dust can escape into the environment.

5. **Dosage**

5.1. The dose rate of the PPP must be possible to read at an easily accessible place.
5.2. To check the dosage, the PPP must be easily and completely collected separately from the seed before treatment.
5.3. The dosage setting must be clearly visible (clearly recognizable).

6. **Emptying / Cleaning**

6.1. It shall be possible to collect the remaining PPP simply, without tools, reliably and without spillage (for example using a tap).
6.2. The complete emptying of containers must be possible to be carried out by one person.

6.3. The cleaning device for crop protection product containers, if provided, shall work reliably.

7. **Fittings**

7.1. All devices for measuring, switching on and off and adjusting flow rates shall work reliably and there shall be no leakages.

7.2. The manual controls which are necessary for the application shall be mounted in such a way, that they can be easily reached and readjusted (if necessary) during the application. Information which is provided e.g. on a display need to be readable presented.

7.3. Other measuring devices, especially flow meters used for the dosage shall measure within a maximum error of 5 % of the real data.

8. **Pipes and hoses**

8.1. There shall be no leakages by pipes or hoses while testing the maximum obtainable working pressure for the system.

8.2. Hoses shall be positioned in such a way, that there are no sharp bends and no abrasion which makes the woven fabric visible.

9. **Filtering**

9.1. If filters are installed in lines, filter inserts shall be changeable.

9.2. If filters are installed: The filter(s) shall be in good condition and the mesh size corresponds to the nozzle(s) fitted in the seed treatment equipment.

10. **Atomizer**

10.1. Atomizer(s) for PPP shall not be affected in their function, for example, by encrustations / dirt.

11. **Cleaning**

11.1. Mixing tank, seed chamber / seed barrel and mixer must be easy to clean. This also means that the equipment is provided with openings for cleaning.

12. **Dosage**

12.1. Dosage indications given as a guideline on the basis of water must at least contain information on the setting up the seed-mass flow as well as the PPP-mass flow (as the circumstances require depending on seed and its volume weight).

13. **Other equipment**

13.1. Other equipment must be functional. Minor defects: The lack of equipment does not affect the application quality of the plant protection device (in particular dose, distribution, fluid loss).
First results from 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[1]. 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 an in-house developed one for soil-disinfection machines[8]. Those inspection protocols were added to the Belgian legislation and implemented from 2011 on[7].

The new protocol for soil-disinfection equipment was developed after an evaluation of existing soil-disinfection machines and was mainly based on the existing Belgian protocols. Due to some safety aspects, the inspection from soil disinfection machines was finally started up in 2014. At this moment, all known soil disinfection machines used on the Belgian territory have been inspected once. Following the inspection of those machines, Belgium felt the need to make some additional changes to the existing first protocol. Some inspection limits were too narrow, some items were inapplicable and new inspection items were added. Those changes were implemented and at this moment, the updated inspection protocol is ready for publication and will be implemented from 2017 on. Based on this new adapted inspection protocol, Belgium also prepared a SPISE advice. The first inspection results and problems encountered during the first inspections will be presented in this paper.

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

Introduction

Since 1995 sprayer inspection is mandatory in Belgium which makes it one of the forerunners in Europe[2]. 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[3]. Now, the Framework Directive for a sustainable use of pesticides introduces the inspection of 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). Both official inspection bodies are 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. 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. All over the country, test locations are hired so that farmers/contractors don’t need to
travel distances above 15 km. 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. Consequently, the repaired sprayer has to be represented for a second passage. The inspection of soil disinfection machines was started up in 2014[7]. This paper describes the working principle, the inspection protocol and the first inspection results.

Working principle of a common soil-disinfection machine.

Figure 1 shows a picture of a typical soil-disinfection machine while Figure 2 shows the corresponding hydraulic scheme containing all elementary parts[7].

![Fig. 1 Typical soil-disinfection machine.](image1)

![Fig. 2 Hydraulic scheme of a soil-disinfection machine.](image2)
Briefly one could divide the scheme into two main parts. On the one side you have the air pressure part (parts 1-8) and at the other side the liquid pressure part (parts 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 companies 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), 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 distributing block (15) with restrictor plates, small taps or narrow tubes distributes the liquid to the different injectors (17). Optionally an analogue or digital flowmeter (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 the injector.

**The Belgian inspection procedure for soil disinfection machines**

In most of the EU countries the inspection is performed by workshops and sprayers can be repaired – if necessary- during the inspection. So finally each machine leaves the workshop with a valid inspection. In Belgium, no reparations are made during the inspection which involves that the owner needs a detailed description of each defect[7].

As a consequence the Belgian inspection methodology is based on the analytical principle which consists in checking separately and independently the performance of the different parts of the machine. Up to 33 criteria are checked in the updated protocol for soil disinfection machines. Some are checked visually (tank contents indicator, ploughshares, etc.) while others are measured (injector flow rate, pressure gauge, etc.). All observations are encoded and stored in a computer with tailor-written software. The analysis is done partly automatically and partly by the inspector, and the inspection report is printed on site. In this report, all dysfunctions are listed and classified according to their seriousness to disturb machine performance, together with advice on how to repair the defect. The combined analysis of the dysfunction and its cause allows to determine the weight of this dysfunction in the inspection results. The dysfunction leads to a rejection if it significantly disturbs injecting results or safety or if its origin is imputable to the user (lack of maintenance). Moreover, dysfunctions leading to a rejection always have to be determined in an objective way based on measurements. Thus, not all checked criteria can lead to a rejection of the machine. From the 33 checked criteria, and from 2017 on, only 9 can potentially lead to a rejection of the soil-disinfection machine[7].

The defects observed during the diagnosis are divided into three different categories[4]+[6]: Category I are defects that automatically result in a rejection and must be repaired within four months. Within this period, the machine must be retested.

Category II defects do not result in rejection, but should be repaired before the next inspection. This means that the user has three years (= one inspection cycle) to repair these defects.
Defects of category III are only informative and aim at improving the general operation of the machine. The user is free to follow these recommendations.

**Overview of the defects of soil disinfection machines**

This overview is based on the inspection results obtained in the 7th inspection cycle (2014-2015-2016) in the Flemish region. In this period, only 16 machines were notified and also inspected. No machines were rejected because only four category I defects were defined and inspections were considered as “trial” inspections with a legal base.

**Defects of category I**

The first inspection protocol was considered as a “trial” one and rejections were only possible for four items:

- Bad attachment of the machine to the tractor;
- No pressure gauge;
- Major leaks;
- Worn nozzles and inhomogeneity of the nozzles.

No real problems were encountered for the first three items. All machines were well attached to the tractor, and there was a pressure gauge present on every machine. There were also no major leaks (>30ml/min).

For the last point, problems were found on a lot of machines. The original intention was to use the analytical method to inspect the injector flow by testing the nozzles or calibrated plates on a nozzle test bench, and measuring the injection pressure on the machine. The first inspections showed that it is difficult, and for some machines even impossible, to use the analytical principle to measure and evaluate the injector flow. Some soil disinfection machines use small tubes, others a section block with self-made calibrated plates, or calibrated plates per injector at injector height, and others use small taps to calibrate the flow for each injector. But even for machines using nozzles or calibrated plates, it was decided not to use the nozzle test bench inside the test van, because of contamination with the hazardous disinfectants. For the above reasons, it was decided to measure the injector flowrate on the machine for all soil-disinfection machines using buckets in combination with a stopwatch and weighing scale or using an orchard test bench, depending on the type of injector. This method results in individual flowrate values for each injector and the overall distribution pattern.

A lot of problems were encountered during those tests and 50% of the machines should have been rejected when following the protocol. However the use of the legal terminology “nozzles” was not correct and during those first inspections it became soon clear that the tolerance limit was quite narrow. It was therefore decided to move this item to a lower category II classification for this first inspection cycle.

**Defects of category II**

Figure 3 shows an overview of the category II defects encountered during the first inspection cycle. An uneven injection pattern was the main problem encountered (50% of the machines). The criterion used was that the flow rate at an individual injector should not differ more than 5% from the average flow rate from all injectors. This is what was legally applied for “nozzles” with unknown reference. This limit was quite narrow and after the
first inspections and discussions in the Belgian technical committee, the 5% limit was increased to 10% which will be used in future. Even with this 10% limit, 6 out of 16 machines did not fulfil this requirement! Main reasons are a bad design and a lack of maintenance.

**Fig. 3** An overview of category II defects for soil disinfection machines during the first inspection cycle (2014-15-16).

Figure 4 shows a typical bad pattern from a bad designed soil disinfection machine, where individual flow rates range from 0,54 l/min (injectors 6 and 7) up to 0,72 l/min (injector 1). A decrease in flow rates can be observed from injector 1 to 7 probably caused by different lengths of the feeding tubes of the injectors, in combination with a dividing block that is dimensioned too narrow. The low flow rate on injector 3 can probably be solved by cleaning the calibration plate.

**Fig. 4** Flow distribution and picture from machine number A13300016.
Figure 5 shows the pattern from a machine using a dividing block with calibrated plates where a low flowrate was observed at injector 7. The reason here is that the 7th injector is not always used and was therefore partially blocked.

*Fig.5 Flow distribution and picture from machine number A13300004.*

Both examples show that a simple pattern test can show relevant problems on the machine. This test can also easily be performed by the owner himself.

Furthermore all machines were equipped with one or more pressure gauges. In all cases, a pressure gauge was mounted on the pesticide tank to measure the air pressure. In some cases, another pressure gauge was present on the liquid circuit.

The pressure gauges are dismantled from the sprayer and tested on a pressure test bench. When the deviation is higher than 10% then the pressure gauge needs to be replaced. This was the case for 3 out of 16 machines. Two machines also showed minor leakages (<30 ml/min).

With one machine there was a problem with the capacity of the compressor resulting in two remarks “repair or replace the bad working compressor” and “pressure instability”. This particular machine used a compressor driven by the tractor hydraulics (Figure 6). Even at the normal nominal working rpm of the tractor, the working pressure dropped after a certain time and could not be maintained, probably because the compressor of this self-made machine was malfunctioning or bad dimensioned.

*Fig.6 Machine with a hydraulically driven compressor.*
Another remark given to a machine using nozzles and after separate testing on the nozzle test bench, was for a worn nozzle (Figure 7).

**Fig. 7** Machine using nozzles underneath a ploughshare.

And at last a machine was given the remark bad state of the moving parts protection. This remark concerned a machine with no protection of the driving chain from the roller.

*Defects of category III*

Those defects are less important, but their reparation will improve machine performance or user comfort and safety.

**Fig. 8** An overview of category III defects for soil disinfection machines during the first inspection cycle (2014-15-16).

These remarks can be grouped into two main categories: remarks concerning the tank contents indicator and remarks about the lack of filters.
Three machines did not have a tank contents indicator. In most other cases, the tank contents indicator was almost unreadable. Figure 9 shows two of these examples where it is difficult to read the tank level. For the right picture it would be better to put measuring marks on the tank.

![Fig. 9 Bad tank contents indicators.](image)

At last, a lot of machines showed problems with the filters. For most of them, no filters at all were present in the liquid circuit. Despite the fact that the pesticide is putted in the tank in its pure form, there were some problems with blocked injectors. It should therefore be considered to mount at least one filter in the liquid circuit. Figure 10 shows a machine without any filtering. This machine was given the advice to use nozzle filters as the easiest solution, because the machine used standard nozzle holders.

![Fig.10 Machine without filters using standard nozzles.](image)
Remarks notified without a legal base

During the first inspections it became soon clear that there were some aspects which were not present in the first inspection protocol. The inspection from those items was performed -if relevant- and noted manually on the inspection reports. Most of them are now implemented in the updated inspection protocol.

Some important safety aspects were observed. For a lot of machines the main tank filling valve (Figure 11A) did not had a safety system to prevent unintended opening. This can cause dangerous situations because if the valve is opened with a pressurized tank, the air with hazardous vapours might be blown towards the operator or bystander. Other machines did not have a tank depressurising valve with a tube that leads the air-flow downwards (Figure 11B). And at last there were machines that missed a safety valve (Figure 11C).

![Fig.11 Pesticide tank with unsafe filling valve (A), safe depressurising valve (B) and safety valve (C).](image)

Most machines are also equipped with a flow meter[5]. In those cases, fine tuning the liquid flow is based on the flow meter and not based on the pressure gauge. No testing was foreseen in the first inspection protocol. Because of its importance the actual measured flow was compared with the flow indicated by the flow meter. None of the flow meters showed inaccuracies above 10%. All these items were introduced in the new protocol.

Conclusions

Because of their specific construction and working principle, there was a need to develop a completely new inspection protocol for soil-disinfection machines. A first inspection protocol was established and implemented. The first inspections revealed some additional problems that needed to be solved. An updated and well balanced inspection protocol was developed and will be used from 2017 on.

The owners of the soil-disinfection machines are -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.
References


Belgian trial protocol for the inspection of cold atomizers

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Summary

In Belgium, the mandatory inspection of field crop, orchard and vineyard sprayers was already started up in 1995[1]. The inspection of greenhouse sprayers and soil-disinfection machines was implemented respectively in 2011 and 2014[11]. Specific Belgian inspection protocols are available for those four types of PAE[9]. The protocols are mainly based on EN 13790 standards, and are updated or adapted on a regular base.

According to the EU directive 2009/128/EC, all pesticide application equipment (PAE) used on the European territory needs to be inspected at least once before 14 December 2016. To deal with Chapter III Article 8 of this directive, a dedicated project funded by the Belgian federal government was started up. Within this project 25 additional types of PAE were defined. For most them there is no appropriate inspection standard available. Because of the slow process of standardisation work, Belgium decided to develop new inspection protocols where needed. This was done, among others, for cold atomisers which are used for atomizing pesticides in closed environments (greenhouses, storage rooms, etc.), generally using a pneumatic method for ultra fine - very fine droplet generation.

In a first stage, an inventory was made of all available standards and inspection protocols. For cold atomisers no specific standard is available. On the other hand, Germany[8], The Netherlands[12] and the UK already have an inspection protocol for this type of machines. In a second stage, the German and the Dutch protocol were reviewed and a Belgian “trial” protocol was drafted. In a third stage, some dealers and manufacturers of cold atomisers were consulted and the protocol was checked for different types of cold atomisers. Based on their feedback, some changes were made. At this moment a complete trial protocol is ready for use and will be presented at the SPISE workshop. In a last stage, this trial protocol will be tested in the field on its accuracy and applicability, before implementing it into Belgian legislation.

Key words: sprayers, foggers, cold atomizers, inspection, trial, defects

Introduction

In many ways, the mandatory inspection of sprayers in Belgium differs from inspections in other European countries[2]+[4]+[5]+[7]. 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). Both 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 (Figure 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 lo-
cations are hired in a way that farmers/contractors don’t need to travel distances above 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. Recently, an inspection protocol for cold atomizers was drafted in order to fulfill the requirements of the EU directive 2009/128/EC.

![Inspection van with test equipment.](image)

**Fig. 1 Inspection van with test equipment.**

**Usage and working principle**

Cold atomizers or cold foggers are mainly used to control pests in closed environments such as greenhouses or storage rooms (Figure 2). In some cases, they are used for outdoor purposes and can therefore even be mounted on a vehicle. Cold fogging is also defined as ultra-low-volume (ULV) or low-volume-moisturizing (LVM) application. This technique produces extremely fine droplets (1-50 µm) for optimal penetration and coverage.

Since the late 1980s, cold fogging technology has grown in importance in greenhouse cultivation[3]. Experience shows that suitable cold fogging machines will achieve an effi-
cient pesticide use and savings of water and energy. With this technology, highly concentrated plant protection preparations are used with water as a carrier, and the application volumes range from 20-60 liter per ha. The optimal application volume depends on the crop, growth stage and the specific application situation, such as the degree of infestation. Stabilizers such as emulsifiable crop oil or polyethylene glycol are used to avoid droplet evaporation and to keep droplets airborne for a longer period.

In general, the following droplet sizes are relevant for:

- flying insects: 10-30 µm
- leaf nematodes: 20-40 µm
- fungal diseases: 30-50 µm

**Fig. 2 Typical cold atomizers.**

During application, the greenhouse must be sealed to avoid any losses caused by leakages or open vents. Cold atomizers that are technically up to date offer many benefits. Fogging causes no dripping losses or spraying stains. Due to the long persistence of the fog, insects are exposed for a longer time compared with a conventional spray. The fog also achieves a good penetration, coverage and adhesion on the leave surfaces. Cold atomizers work fully automatic, so contact between operator and chemicals is minimized to filling the tank. The workload of fogging is low compared with the time and labor required for conventional spraying, because the unit can be used after normal working hours in the greenhouse. The noise level is also limited compared to motor-driven sprayers or thermal foggers.

**Working principle of a common cold atomizer (LVM/ULV)**

In order to clarify the trial inspection protocol for those machines, one first needs to know how this type of machines works.

Most cold foggers use a pneumatic method of droplet generation. The overpressure is obtained by an airstream produced by a blower, a compressor, or the outlet side of a vacuum pump. The fogging solution is conveyed at the nozzle system by this overpressure (venturi effect) and atomized into a fine aerosol. Usually, the droplets are transported by a controlled airstream driven by an optional fan installed on the unit. The droplets are distributed even-
ly within the greenhouse by horizontal and vertical air circulation. For larger greenhouses extra fans are used to distribute the droplets, or multiple cold foggers are placed in the greenhouse. Main advantage of the system is that due to the very low underpressure at the nozzle, the nozzle has a relatively large orifice which avoids nozzle blockage.

In order to better understand the working principle, some commonly used types are discussed below. Figure 3 shows a “Wanjet”. This machine uses a nozzle with a flow regulation valve integrated in the blower. Furthermore, the blower itself is integrated in the fan housing and placed before the fan. This makes a compact housing possible. Several of those LVM’s can be placed all over the greenhouses, and only an electrical supply is needed.

![Fig.3 Wanjet cold fogger.](image)

Figure 4 shows the “Enbar” units. Those units exist out of a fan with an air/liquid mixing nozzle. The air supply is obtained by an integrated or external compressor.

![Fig.4 Enbar: left with fixed units, fed by a central compressor and right with an integrated compressor.](image)

Figure 5 shows a typical scheme and parts list from a cold fogger with a blower and a flush system. All relevant parts are numbered and are explained beneath[10].
Fig. 5 Scheme and parts list from a cold fogger using a blower.

The pesticide formulation tank (1) is a closed tank that is pressurized through the blower (12). The pesticides in the tank are agitated using the pressurizing air from the blower, mechanically, hydraulically or a combination of former. In this particular scheme the agitation is obtained using pressurized air from the blower (12) in combination with an additional hydraulic agitation pump (3). An optional filter (8) is sometimes present in the pesticide liquid line and in some cases a fluid sensor (4) measures and shows the actual flow for control purposes. The pesticide solution is directed to the nozzle (7) in the air swirl head (14) using a 3-way solenoid valve (5). Different systems are used to calibrate the liquid flow. In this case a liquid metering valve (6) is positioned in the liquid line. In other cases the nozzle can be replaced by another nozzle with a different orifice size to adjust the flow. When the system uses a nozzle to calibrate the flow, a nozzle table is supplied from the manufacturer. When a metering valve is used, a simple table indicating the flow depending on the number of turns from the metering screw (6) is supplied. Using the 3-way solenoid valve (5), clear water from the flush tank (9) can be run through the liquid line in order to clean lines and nozzles.

The blower (12) with air filter (11) moves a large amount of air through the air swirl head (14). Sometimes a compressor or vacuum pump is used to generate the air stream. The circular air forces at the swirl head (14) create an under pressure and dispense the liquid into small particles. Furthermore, the air also creates a negative pressure into the liquid lines. This liquid under pressure causes the liquid to be drawn from the formulation tank. Some systems only use this negative pressure to draw the liquid from the pesticide tank, but others also use the blower to pressurize the pesticide tank (see Figure 6), and sometimes an extra small liquid pump is installed to have sufficient flow rate. An extra optional fan (10) blows the vapor into the closed environment. Sometimes extra fans are used to disperse the vapor. At last an electrical control box (15) can be foreseen to perform a complete automatic treatment. With the control box it is possible to set a pre-vent time (to obtain pre-circulation), an application time with intervals, a system flush and an after-vent.
Most machines are mainly based on the same principle. The main variations that were encountered are the type of nozzle body and the type of pressurization of the nozzle (compressor, blower or vacuum pump). There are also some types without a fan (10) on board. Those types are normally used in smaller rooms. (disinfection, potato sprout inhibiting, etc.).

**Inspection method**

**Admittance rules**

Before starting up the actual inspection, all admittance rules are overlooked. The machine needs to be presented in a clean state and all moving parts must be well protected. The pesticide tank has to be filled for ¾ with clean water and the machine may not show any big leakages. Furthermore the owner is asked to present the flow rate table for the machine. Depending on the type of machine this can be a nozzle flow rate table, or a table presenting the flow rate for the different metering positions of the metering valve (Figure 6).

![Example of nozzle flow rate table (in Dutch) with liquid metering valve settings.](image)

**Fig.6** Example of nozzle flow rate table (in Dutch) with liquid metering valve settings.

**Part 1: Inspections performed before starting up the machine**

In a first stage some items are checked visually before starting up the machine. The general maintenance condition is evaluated, and the electrical installation is overlooked. Cables and plugs are checked visually and must be in a good condition and the grounding of the metal parts is checked. The hoses and pipes are also checked for cracks or wear.

Then the tank is inspected. The tank contents indicator is checked on its presence and readability. It is checked if the tank can be cleaned easily and if the lid and all connections to the tank are in a good condition. In most cases the tanks are demountable for easy filling and cleaning.

As concerns filtering, a filling strainer and/or a filter in the liquid line is advised. Because a lot of machines use standard jerry cans as a pesticide tank, a filling device with a strainer (Figure 7) is a possible solution if there is no filling strainer in the tank opening.
In a next stage the state of the fan is evaluated (Figure 8). The fan needs to be well protected by a grid that should be in a good condition and properly fixed. The fan blades must have their original shape and the bearings of the fan motor have to be in good condition (abnormal noises).

Then the machine is overlooked for the presence of a measuring device to monitor the current flow settings. Some machines have a manometer present to adequately set the nozzle air pressure, others have a flow meter in the liquid line, but unfortunately in a lot of cases no measuring device is present at all. If a manometer is present, it is tested on a manometer test stand. Flow meters are tested in a later stage of the inspection. If there is no measuring device at all then it’s advised to install one, preferably a real time flow meter.

Concerning the pressurizing system from the nozzle, a compressor, a vacuum pump, or a blower is used. All three systems are basically checked for the same items. They have to be well maintained and pressure hoses and couplings have to be in a good state. Furthermore the air filtering is overlooked, especially on the blower this is a very important item (Figure 10). If the nozzle body uses air swirl plates (Figure 9) to create the under pressure at nozzle height then those swirl plates are visually checked.
Part 2: Starting up the machine and inspection of the general functioning

In a second stage the machine is started up and it is checked if all controls are working properly. Special attention is given to the pressure valve (Figure 11) if a compressor is used, and to the flow regulating valve (Figure 6) if a blower is used. The correct functioning of both valves is checked, by varying the pressure or the flow during normal functioning of the machine.

![Fig.11 Air pressure valve (air pressure type).](image)

Then the owner is asked to set the equipment in its normal usage settings and the pressure stability and/or flow stability is evaluated. No stability differences (pressure or flow) bigger then 10% are allowed. At the same time the fog is visually evaluated. The fog needs to be evenly dispersed and there may not be any obstacles in the fog range. During fogging it is also checked if the tank agitation system does its work. At last the machine is also overlooked for leakages.

Part 3: Nozzle flow check.

As one knows a good functioning from a cold fogger is obtained by generating the correct droplet spectrum. One of the main characteristics directly related to the droplet spectrum is the liquid flow. If the actual liquid flow corresponds with the nominal liquid flow what the machine was designed for, one can assume that the machine generates the correct droplet spectrum and the machine is well functioning.

Most cold foggers use a pneumatic method of droplet generation and there are mainly three different ways to calibrate the liquid flow.

At first there are machines with a constant and fixed overpressure, using different nozzle sizes to calibrate the flow. A table should be available with the different flow rates for the different nozzles (Figure 12).
Secondly there are machines using a fixed nozzle size and a possibility to vary the over-pressure (Figure 4 and Figure 11). Varying the overpressure in the nozzle body gives a different flow rate, so a table indicating the flow rate in relation with the air pressure should be supplied.

At last there are the types using a fixed overpressure in combination with a fixed nozzle body and a metering valve in the liquid line to change the flow. The liquid flow rate table for different metering valve settings should be supplied (Figure 6).

The most simple test method to test the actual flow is to measure the amount of liquid actually used for a certain time. For machines using small removable tanks, the tank is filled with ¾ of clean water and weighed. After fogging over a certain period, the tank is weighed again and based on time and weight difference the actual flow can be calculated. The result is compared with the table, and at this moment, the tolerance is set at a maximum difference of 15%. On machines with larger tanks, accurate weighing shall not be possible. One of the possibilities is to put a mark on the tank at the actual water level height and then add with a measuring cup a calibrated amount of water to the tank. Atomizing shall be started and when the tank level reaches the level mark, timing is stopped.

**Fig. 12** Cold fogger with the possibility to install different nozzles.

**Fig. 13** Cold fogger large tank, and using of a marking.
Despite the fact that this method gives an accurate result on the real actual flow rate, the main disadvantage of this test method is its duration. As one can see in the presented tables, volumes vary from 2 to 10 liter per hour. This means that if a machine with a large tank must be inspected and the machine atomizes only 2 l/h it takes quite a long time to have an accurate measurement.

This is one of the reasons why we foresee to use a small flow meter with digital read out[6]. This flow meter should be plugged into the liquid end line, somewhere before the nozzle. Because most of the equipment uses standard silicone tubes in most cases this should not be a problem. Furthermore it’s important that the flow meter is not a paddle-wheel type or similar, because those will give a slight resistance with a pressure drop as a consequence. This could influence the results so there should be looked for an electromagnetic or ultrasonic type.

Conclusions
Because of their specific construction there was the need to develop a complete new inspection protocol for cold atomizing machines. A first inspection protocol is ready to use to perform the first actual inspections of those type of machines in Belgium. The only disadvantage of the actual method is the long duration of the flowrate test. The consequence will be a high pricing for relatively small machines.

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Test methods not yet covered by EN-ISO 16122, micro granule application and slug pellet applicators

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With no EU standard available for testing micro granule applicators, the NSTS devised a protocol about 8 years ago. Discussions were held with industry representatives from machine and product manufacturers, farmers and machine specialists and a test standard was produced. With the introduction of Directive 2009/128/EC (Sustainable Use Directive) there is now the requirement to test slug pellet application equipment and this standard was achieved again with full industry involvement. The main objectives are accurate application, environmental and operator safety and food security. Test reports are produced and in the case of slug pellet machines, as with sprayer testing, this is done electronically with the aid of an app. Full training is available and a recognised qualification is required for each test procedure before an examiner can start testing machines.

Part 1: Micro-granule applicator

Introduction

While EU standards for boom sprayers and bush and tree crop sprayers are available, there is no recognised standard that applies to micro-granule applicators. The UK has a requirement for such machines to be tested; therefore the National Sprayer Testing Scheme in the UK, NSTS, devised a suitable test to meet the requirements of Directive 2009/128/EC (Sustainable Use Directive) as well as industry, grower and supermarket protocols.

This protocol has been agreed by machine manufacturers, product manufacturers, farmers and growers and purchasers of the produce. The main drivers have been accurate application, operator, environmental and food safety.

Machines

The application machinery involved in the application of micro-granules is many and varied. They can be either stand-alone machines or attached to other machines, such as drills, planters and rolls.

Examples of machine configurations available are below –
Products

Products come in two basic types; those used during planting, are incorporated with the seed and used on potatoes and root vegetables crops for the control of nematodes and other soil borne pests. These products have restrictions under The Poisons Act and also have operator and environmental restrictions.

The second types are herbicides used in the autumn, predominately in cereal crops to control blackgrass and wild oats.

Machine examiner qualification

There is no agreed standard for testing these types of machines, equally no qualification for machine examiners exists. Thus NSTS had to devise its own examiner training programme and relevant qualification suitable for examiners. There exists in the UK, a City & Guilds Certificate of Competence for operators of these types of machines and elements of this were taken into consideration when devising the NSTS qualification for examiners.

Equipment required for testing machines

Each Test Centre offering the granule applications test must have specified equipment available as well as qualified machine examiners.

The specified equipment required is listed below:

- Electronic scales able to weigh to 2 grams (or better), these should be regularly checked against a known check weight (write the weight of the jug on the jug and check every day).
- Calibrated weight, e.g. 200g.
- Spare battery for the scales (in cold weather keep one warm in a pocket).
- Sufficient containers suitable for various machines being tested in order to collect granules for weighing, these should allow air to exit while collecting product.
- Feeler gauge as recommended by manufacturer (standard gauge sets are too narrow to be effective).
- A 3 metre or longer measure tape (a cord with a loop in one end or a flexible cloth measure tape makes spider wheel circumference easier to measure).
- Anemometer
- Examiner PPE as required by product label

Advice on the product label should be adhered to when handling the product or testing machines that have applied the product. Personal Protective equipment (PPE) as specified on the product label should be worn. While placebo products, those without the active ingredient, are available, they may have different flow characteristics and may well give different results when calibrating the machine.

DO NOT WORK ON MACHINES USED TO APPLY THESE PRODUCTS IF UNDER MEDICAL ADVICE NOT TO DO SO.

**Machine preparation for testing**

- Machine preparation:

The machine should be cleaned thoroughly by the operator before being presented for inspection. The machine guards must be complete and in place.

MACHINES OFFERED FOR TEST MUST BE IN A CLEAN AND DRY CONDITION AND CONTAIN NO TRACES OF OLD PRODUCT.

Used granular applicator machines should always be treated as contaminated. The majority of products used are nematicides or insecticides. These are mostly anticholinesterase compounds.

Appropriate Personal Protective Equipment (PPE) MUST BE WORN. See product label.

A copy of the manufacturer’s instruction manual should be available and, where live product is to be used, a copy of the pesticide label.

**Place of inspection**

The test should take place where all environmental considerations can be met and external factors, wind rain etc., do not influence the result.

IF LIVE GRANULES ARE TO BE USED FOR THE OUTPUT TEST, FULL PPE MUST BE WORN AS ADVISED ON THE LABEL FOR THE PRODUCT BEING USED.

**Pre-test inspection**

The machine should be inspected by the examiner for cleanliness and safety before commencing the test.

**Procedure for testing**

- Guards including PTO shaft
All guards particularly PTO, fans, drive shafts, pulley’s etc., must be in place and in good condition

**Visual inspection**

- **Structural wear and corrosion**
  
  i. The structure of the applicator shall be in good condition and without permanent deformation. Significant corrosion could also affect the structural integrity.
  
  ii. Visual inspection

- **Hoppers and lids**
  
  i. All hoppers shall be connected to the applicator correctly and any seals undamaged and intact. Hopper lids should be correct and not allow the ingress of water.
  
  ii. Visual inspection

- **Security of mounting points**
  
  i. The applicator shall be properly fitted to the tractor or towing vehicle. Where the applicator is mounted on another machine i.e. planter or drill, all fixing shall be secure and intact.
  
  ii. Visual inspection

- **Transport latches and restraints.**
  
  i. Where applicable, ensure booms are held securely for transport
  
  ii. Check all drives mechanisms can be secured for transport
  
  iii. Visual inspection

- **Accessibility for hopper filling**
  
  i. Ensure the method of filling hoppers is safe and with health and safety guidelines
  
  ii. Visual inspection and discussion with operator

- **Land-wheel drive**
  
  i. Where applicable measure and record the circumference of the drive wheels
  
  ii. Record the number of turns required for 100metres
  
  iii. Check electronic signal from GPS or radar sensors is functioning correctly
  
  iv. Check drive disengagement functions correctly
  
  v. Measurement and practical operation

- **Drive pulley/sprockets**
  
  i. Record the sizes of both drive and driven sprockets available with the machine
  
  ii. Available drive pulleys must be suitable for the type of product being used
  
  iii. Visual inspection

- **Metering shaft alignment**
  
  i. Where appropriate metering shaft alignment shall be correct and to manufacturers guidelines
ii. Measurement and practical operation

- Metering rotor condition
  i. Ensure metering units are correct for the product being used
  ii. Check rotors for damage and debris, any damaged rotors must be replaced
  iii. Ensure rotors and cassettes are fitted according to manufacturers guidelines
  iv. Visual inspection

- Measure rotor clearance
  i. Ensure gaps between rotors and rotor casing is according to manufacturer’s guidelines
  ii. Check for signs of wear in cassettes and that any brushes are in good condition
  iii. Visual inspection and practical checks

- Delivery system
  i. Ensure the delivery system is complete and in good condition
  ii. Ensure all spreader plates are correct and angles are as per manufacturers guidelines
  iii. Ensure all angled bends are undamaged and of the correct length, check manufacturers guidelines for details
  iv. Visual inspection
• Pipework and delivery tubes  
  i. Check all hoses and pipework are undamaged and do not leak  
  ii. Check all pipework for internal obstructions  
  iii. Visual inspection  
• Fish-tail and deflector plate condition  
  i. Ensure fish-tails or spreader plates are in good condition and within manufacturer’s guidelines  
  ii. Ensure the number of fishtails is sufficient for the spread of product for the width of application required  
  iii. Check fish-tail deflector plate height is according to manufactures guidelines and product label requirements  
  iv. Visual inspection  
• Boom alignment (if fitted)  
  i. Check boom is straight and level, outlets should be within 1% of half boom width in the horizontal plane and shall not deviate more than +/-2.5% in the forwards and backwards plane  
  ii. Check all boom mounting points are correct and secure  
  iii. Check boom break-backs if fitted  
  iv. Visual inspection and practical measurement  
• Height adjustment/suspension (if fitted)  
  i. Check boom suspension works as design specification and maintains a level and straight working alignment  
  ii. Visual inspection
• Closed transfer Systems
  i. Check closed transfer is fitted as per manufacturers guidelines and correctly aligned
  ii. Check seal is intact
  iii. Visual inspection

• Fan and air-flow
  i. Ensure fan in running in correct direction
  ii. Check fan speed/pressure is within manufacturers guidelines
  iii. Ensure air-flow is even across the width of the boom and to manufacturers guidelines
  iv. Air-flow to be checked with PTO running at 540rpm or speed stipulated by the manufacturer
  v. Check venturi is to manufacturers guidelines

• Output check with appropriate material
  i. Set machine to give an appropriate output for the material being used or the intended application rate of the test is to be part of the calibration procedure
  ii. Output to be the equivalent of 100 metre application or at least 100 grams per outlet
  iii. Air assisted machines collect granules in a suitable container which will allow air to escape while retaining granules
  iv. Minimum resolution for output collection is 1 metre
  v. Outputs must be within +/-10% of the mean collected
  vi. Record outputs on test report sheet
  vii. Practical output check and measurement

• Optional distribution test
  i. Select suitable corrugated sheets to 0.5 metre resolution and of suitable depth to collect the amount of product being used for the test
  ii. Distribution time to be sufficient to give a weighable amount
  iii. Minimum distribution check width to be 6 metres
  iv. Record outputs on test report sheet
Post Test procedure

On successful completion of the testing the completed test report shall be forwarded to NSTS Administration within two weeks. The appropriately numbered decal shall be displayed prominently on the machine and a copy of the test report provided to the machine owner.

All granules used during the test must be collected, put into an original container for that product and returned with the machine for safe and proper disposal by the owner.

Following the test, the operator should carry out a calibration check prior to commencement of application (in particular when dummy granules have been used during the test). Additional regular calibration and maintenance checks should be carried out during the season.

Part 2: Pellet applicator

Introduction

While EU standards for boom and bush and tree crop sprayers are available, there is on such recognised standard that applies to slug pellet applicators. The UK has a requirement for these machines to be tested; therefore the National sprayer testing Scheme (NSTS) devised a suitable test to meet the requirements of Directive 2009/128/EC (Sustainable Use Directive) as well as industry, grower and supermarket protocols.

This protocol has been agreed by machine manufacturers, product manufacturers, farmers and growers and purchasers of the produce. The main drivers have been accurate application, operator, environmental and food safety.
Machines

The application machinery used to apply pellet are many and varied they are either small applicators attached to ATV’s or UTV’s but can also be attached to rolls, sprayers and drills. Machines are be simple in their workings with low purchase costs and are varyingly used depending on season and slug infestation numbers.

Some examples of machines configurations available are shown below –
Products

Pellet for the control of slugs are the most common product applied by this kind of application machinery. Slugs, a gastropod mollusk, are a pest to young crops particularly cereals, oilseed rape (canola), where crops are grazed and often killed. They also attack potato crops which can substantially reduce saleable yield. The majority of slug pellets contain Metaldehyde, which can be found in water, being almost impossible to remove. This has led to exceedances of the Water Framework Directive tolerances, which could lead to a ban of these products. An alternative product for slug control, Ferris Oxide, is available which is applied by the same machinery in the same way.

Slug pellets are available from a number of different sources and vary in their manufacture. The common type being either dry or wet pressed pellets and have very different ballistic qualities which give inconsistent spread characteristics between products.

While even application across the width of spread is required, there is also a need to know the extreme width of pellet spread to give accurate bought width when applying around the outside of fields and against hedge rows and water courses.

Products are often applied at low applications rates, around 30 pellets per m², typically 3 - 5 kg/ha.

Machine examiner qualifications

There being no agreed standard for testing these types of machines. There was equally no qualification for machine examiners. Thus NSTS with City & Guilds have to devise its own examiner training programme and relevant qualification suitable for examiners. There exists, in the UK, a City & Guilds Certificate of Competence (PA4) for operators of these types of machines and elements of this were taken into consideration when devising the NSTS qualification for examiners.

Equipment required for testing machines

Each Test Centre offering pellet applicator testing must have specified equipment available as well as qualified machine examiners. The specified equipment required is listed below:

- Minimum of 20 collection trays, 0.5m x 0.5m with internal baffles to stop pellet bounce
- Granolometer
- Hardness tester
- Litre measure and scales
- Examiner PPE as required by product label

Advice on the product label should be adhered to when handling the product or testing machines that have applied the product. Personal Protective equipment (PPE) as specified on the product label should be worn. Placebo ‘dummy’ product, those without the active ingredient, are available, however is some cases may have different flow characteristics and may well give different results when calibrating the machine. These factors must be taken into account when testing machines.
**Machine preparation**

The machine should be cleaned thoroughly by the operator before being presented for inspection. The machine guards must be complete and in place. **MACHINES OFFERED FOR TEST MUST BE IN A CLEAN AND DRY CONDITION AND CONTAIN NO TRACES OF OLD PRODUCT.**

Used granular applicator machines should always be treated as contaminated. Appropriate Personal Protective Equipment (PPE) MUST BE WORN. See product label. A copy of the manufacturers’ instruction manual should be available and, where live product is to be used, a copy of the pesticide label.

**Place of inspection**

The test should take place where all environmental considerations can be met and external factors, wind rain etc., do not influence the result. **ALWAYS USE PLACEBO PELLETS, HOWEVER IF LIVE GRANULES ARE TO BE USED FOR THE OUTPUT TEST, FULL PPE MUST BE WORN AS ADVISED ON THE LABEL FOR THE PRODUCT BEING USED.**

**Pre-test inspection**

The machine should be inspected by the examiner for cleanliness and safety before commencing the test.

**Procedure for testing**

- Guards including PTO shaft
  - All guards particularly PTO, must be in place and in good condition
  - Visual inspection
- Hoppers and lids
  - All hoppers must be sound and any seals undamaged and intact. Hopper lids should be correct and without cracks and should be firmly fixed when in the closed position.
  - Visual inspection
- Structural wear and corrosion
  - The structure of the applicator shall be in good condition and without permanent deformation. Significant corrosion could also affect the structural integrity.
  - Visual inspection
- Security of mounting points
  - The applicator shall be properly fitted to the ATV/UTV or implement. Where the applicator is mounted on another machine i.e. planter or drill, all fixings shall be secure and intact.
  - Visual inspection
• Aperture mechanisms
  i. Check aperture mechanisms function correctly and shut fully when in closed position
  ii. Mechanical function and visual inspection
• Disc spinning freely
  i. Ensure disc spins freely with no jamming or catching
  ii. Mechanical function and visual inspection
• Disc speed
  i. Check disc speed is within range of manufacturers guidelines, check with optical tachometer
  ii. Mechanical function
• Disc condition and vanes
  i. Check disc vanes are in good condition and at correct settings, according to manufacturers’ guidelines
  ii. Visual inspection
• Pellet drop-on point
  i. Ensure product drop on point as set to manufacturers’ guidelines
  ii. Measurement and practical operation
• Product to be used
  i. Using sample of product, check for hardness and record readings
  ii. Weight 1lt of product and record
  iii. Using granulometer establish segregation of pellet sizes and record
  iv. Use placebo pellets where possible
  v. Practical tests and measurement
• Set trays out
  i. Trays to be placed at 2metre spacing either side of centre line, to the suggested spread width. A further tray 2metres is placed and the gap between the last tray and the penultimate and filled with touching trays.
  ii. In all cases the centre tray is dispensed with
  iii. Practical test and measurement
  iv. Ensure placing of trays allows for direction of wind, test by going into or with the wind, NOT cross wind.
• Drive applicator over trays
  i. Using a suitable speed drive the applicator across the line of trays with the disc spinning and product being spread
  ii. Practical test and measurement
  iii. Only one pass required
• Count pellets
  i. Count pellets caught in each tray and record as left and right
  ii. Add amounts on left together and same with right
  iii. Calculate the average – left and right MUST be within 15% of the average
  iv. Practical test and measurement
• Adjust if required
  i. If pellet count is outside the tolerance, adjust machine and retest over trays
  ii. Practical test and measurement
• Record settings
  i. Record all settings for future reference

**Successful completion of the test**

On successful completion of the testing the completed test report shall be forwarded to NSTS Administration within two weeks. The appropriately numbered decal shall be displayed prominently on the machine and a copy of the test report provided to the machine owner.

Following the test, the operator should carry out a calibration check prior to commencement of application (in particular when dummy granules have been used during the test). Additional regular calibration and maintenance checks should be carried out during the season.
Session 4

“Certification” of the Workshop activity (quality assurance) included the certification of devices/ instruments used for the inspections

SPISE TWG 4: “Certification” of the workshop activity (quality assurance) including test facilities

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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 inspection 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 inspection is the requirements in the European Directive 2009/128 article 8 and Annex 2. These requirements in Annex 2 are for the most common sprayer types in detail specified in the harmonised 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 these standards and from whom 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 harmonised 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. Therefore SPISE has created this Working group to define a SPISE Advise which contains guidelines on how certificate the activities of the workshops who performs the inspections. The guideline will contain an example of a quality assurance scheme, what will include the activities of the workshops but also the activities in the total inspection scheme needed to guarantee the constant quality of the performed inspections.

This 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.
Importance of the quality of the Workshop activity

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Summary
In the Directive 2009/128/EC of the European Parliament and of the Council establishing a framework for community action to achieve the sustainable use of pesticides is stated in Article 8 that „Each member state establish certificate system designed to allow the verification of sprayers inspection…“. In 2013 was submitted by the European Commission the Proposal for a regulation on official controls. This proposal had intention to submit the inspection of sprayers in use 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/. Latest available document states that /the rules detailing the requirements for the sustainable use of plant protection products laid down in Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides include in Article 8 thereof, provisions on the inspection of application equipment which will continue to apply while the rules on official controls of this Regulation should not apply to those inspection activities/.

Keywords: inspection of pesticide application equipment, quality assurance.

Introduction
WG SPISE has spent many years trying to create a system for mutual recognition of inspection of pesticide application equipment. Those issues are discussed at SPISE Workshops and TWG SPISE meetings. For a good mutual recognition of performed inspections between the different member state in the EU, a uniform basic system of quality management 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 procedure about how to deal with non-conformities.

The basic element of such a quality assurance scheme needs to be implemented through all Europeans 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 pesticide application equipment in use with support of the users of sprayers.

Current situation
Reflection on the quality system, which should be a part of regular inspections of pesticide application equipment in use that could be used by the mutual recognition of the test results. We have been already working with the directive 2009/128/EC for the past seven years. At the end of this year (14th of December 2016) should be all used pesticide application equipment inspected at least once. Will be?! The situation in the EU after the release the Directive 2009/128/EC have changed. In many Member States, rather for the worse. Member states which have introduced a functional system of regular inspections of pesticide application equipment (usually
with an interval of 2-3 years) are currently under pressure from politicians and some NGOs which promote that these systems governed according the Article 8 of (in particular as regards the period of 5 years).

They try enforced requirements that regular checks are rather stifle than to be at least maintained at the established level. The five-years interval is too long and a lot of workshops were closed. If the interval under Article 8 of the Directive will be shorten again after 2020 year back to three years it is currently difficult to answer. We will see.

It could be said that the frequency of inspections of pesticide application equipment in some countries is decreasing. Until that time passes a lot of time, it will be treated a lot of hectares of agricultural land and applied a lot of pesticides. This situation is not good especially at a time when addressing the issue of protection of water sources and environment and are recorded ongoing efforts to reduce the use of pesticides. Will be implemented in all member states three years interval for inspection of pesticide application equipment?

SPISE WG seeks to process and prepare individual aspects of the inspection of pesticide application equipment into simple manuals (SPISE Advice) that each member states may help to use uniform procedures for periodic inspections. It’s a difficult job with an unpredictable result.

The situation at regular checks nowadays is not simple and uniform. TWG 4 Quality Assurance is working on a SPISE Advice, which should all member states provide simple instructions on how to deal with Quality Management within the inspection workshops.

What is important for QAS workshop?

The inspection will be done by workshops what meet the requirements only. Workshops are inspected periodically (according the ISO 16122 the testing equipment must be inspected yearly).

Inspection scheme is organised from country to country with more or less differences and depends on specific national legislation, political situation and history. Most general is organisation where a national body is responsible for correct leading and supervision and recognised workshops which inspect the pesticide application equipment of the farmers.

Workshop requirements

- Type, size and focus of the inspection workshop
- Number of inspection staff/operators
- Location of workshop – to carry out safe and environmentally friendly testing, periodical checks, how to deal with mobile inspection (different testing places for inspection).

Requirements for testing equipment

- Based on ISO 16122
- Correct maintenance, regular calibration and checks of equipment; calibration made by independent bodies/labs or provided by manufacturer of testing equipment.
Requirements for workshops staff

- Regular training - knowledges about inspection, types of sprayers/application equipment
- Refreshing courses - periodicity, length, content

Testing protocol, test report

- Specific testing protocol for each types of application equipment, based on ISO 16122 - contain minimum information.
- During the inspection of the workshops will be dealt with check of administrative demands, skills of staff, inspection site meet the requirements, presence of testing equipment and its condition and discussion of results of the inspection with staff and responsible people at workshop. Standard checklist can be a part of registration system.

Conclusion

The requirements for the sprayers in Annex 2 of the Framework directive 2009/12/EC and the standards EN ISO 16122 series are a good base for inspection of pesticide application equipment in use in European Union. For uniform inspections between member states of a high level of quality which is needed to reach enough support among the owners of pesticide application equipment and for effective mutual recognition a system of Quality assurance is need to be establish and harmonised. Many of member states use some kind of quality assurance systems but big differences between countries are still obvious.
Belgian quality assurance system according to ISO17020 illustrated by a practical example.

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Summary

The Federal Agency for Food Security is responsible for the sprayer inspection in Belgium, and the inspection is delegated to two regional inspection authorities. Each regional authority has a central secretariat and several inspection teams.

The Belgian inspection was started up in 1995, and at that time there were no uniform rules on how to guarantee and guard the general quality of the work performed by the two regional inspection services. After some years, experience showed that some problems occurred on a regular base due to a lack of tight rules. There were also minor differences between the regional inspection services as concerns interpretation of the federal legislation. As a consequence, the Federal Agency required from the inspection bodies to have an ISO 17020 certification in 2011.

Starting up certification demanded a big effort from the inspection authorities, but nowadays the quality assurance system is running with an acceptable amount of effort. Besides the extra work and costs, there are also a lot of advantages following out of the certification. This will be illustrated by means of a practical example i.e. The calibration and validation of the nozzle test benches used by the accredited inspection services.

Key words: pesticide application equipment, inspection, quality assurance system

Introduction

The Federal Agency for Food Security is responsible for the sprayer inspection in Belgium, and the inspection is delegated to two regional inspection authorities, respectively:

- the Institute for Agricultural and Fisheries Research (ILVO), Technology & Food Science Unit, Department of Agricultural Engineering, responsible for the Flemish region and the Brussels capital region (Figure 1);
- Agricultural Research Centre (CRA-W), Agricultural Machines & Facilities Unit, Department of Production and Sectors, responsible for the Walloon region and the German speaking region (Figure 1).

Each regional authority has a central secretariat and inspection teams.

Fig. 1 Geographical organisation of sprayer inspection in Belgium
The Belgian inspection was started up in 1995 with the publication of a Ministeri-
al Decree (Belgian official journal, 1995). The Decree described the missions of the
regional inspection services, appeal and conditions linked (definitions, organisation
and financing, appeal, etc). Further directives were given in the annexes:

- Concerning the technical aspects of the inspection, the list of the inspect-
ed points with brief descriptions of the methods, some numerical tolerances
and finally a classification of the defects (“serious deficiencies”, “deficiencies
to monitor”, etc.);

- Official forms (declaration form, report canevas).

At first, the Decree seemed to be well redacted, with enough precisions and rules to
allow a uniform inspection in Belgium. But the experience showed that, due to region-
al differences and the need to add further precisions to the Decree, the two inspection
authorities tended to develop minor differences in terms of organisation and method.
The main differences faced by the two inspections are listed below:

- More sprayers in the Flemish region (>12,000, and less than 7000 for the Wal-
loon region)
- More types of sprayers in the Flemish region (4 types, but 2 for the Walloon
region)
- Different equipment providers respectively for the ILVO and CRA-W
- Different advantages/disadvantages to organise the inspection in each re-

region

The two teams evolved in parallel, facing different conditions, leading naturally to
some respective adaptations and particularly some interpretations to fulfil all the ar-
ticles and annexes of the Ministerial Decree. Furthermore, the lack of “ring tests” or
in-situ observations between the authorities didn’t help to detect all the divergent
evolutions. At that time there were no uniform rules on how to guarantee and guard
the general quality of the work performed by the two regional inspection services.

After some years, some problems occurred on a regular base (repetitive demand of
evolution of the Decree, discussions during steering committee and technical com-
mittee) due to a lack of tight rules. As consequences the Federal Agency required
from the inspection bodies to have an ISO 17020 certification in 2011. In addition, the
Decree is reviewed and adapted every cycle of inspection (3 years) on base of a bot-
tom-up approach (from the technical teams to the Federal Agency).

Starting up certification demanded a big effort from the inspection authorities, but
nowadays the quality assurance system is running with an acceptable amount of ef-
fort and time. Besides the extra work and costs, there are also a lot of advantages
following out of the certification. This will be illustrated by means of a practical ex-
ample: the calibration and validation of the nozzle test benches used by the accredited
inspection services (Figure 2).
The nozzle test benches (“NTB”) used in Belgium for the sprayer inspection measure the flow rate of the dismounted nozzles, regardless of the sprayer, and for a fixed pressure (Huyghebaert, 2001). The result is then compared to the nominal value of the nozzle (given by the manufacturer). Used with specific soft wares, it can also calculate the wear rate of a single nozzle or a whole set. The concept permits to avoid all external influences on the measurements (defects of the sprayer itself, settings of the farmer, etc.) and to work under higher controlled conditions, what suits the best for an analytical approach of the inspection.

A nozzle test bench is generally composed of an electromagnetic flow meter and a piezo-resistive pressure sensor (or at least a dial pressure gauge). The automatic data acquisition in the computer is optional and a manual data encoding can be used instead.

**Integration of the nozzle test bench to the quality assurance system ISO 17020**

This chapter aims at scanning the ISO 17020 (ISO, 2012) and filtering all the articles linked to the use of NTB as inspection equipment. Various chapter of the ISO 17020 standard are linked to the use of inspection equipment (and not only the chapter 6.2 “Facilities and equipment”), directly or indirectly. Information management like recordings (7.3.1, 6.2.15, 8.7.1) or use of informatics (6.2.13, 7.1.7, 7.1.8) and human resources (trainings) (6.1.5, 6.1.8) are involved.

The present paper will focus on the metrology, and for every selected article of the standard, relevance and implementation will be presented.

The very first article to be taken into account is the following:

"7.1.1 The inspection body shall use the methods and procedures for inspection which are defined in the requirements against which inspection is to be performed. […]"
It puts directly the obligation to define well the relevant references to follow. It helps practically the technical team to decide which reference has priority in the definition of the technical needs of the inspection. From the Belgian inspection point of view, the existing national legislation is the very first stage of definition of the inspection (articles and annexes). Since 1995, multiple revisions of the initial Ministerial Decree have been published, until the actual Royal Decree (Belgian official journal, 2014). Obviously, this article also reminds the Quality Responsible to check that the procedures are always following the law and its changes from cycle to cycle. In addition to national law, it is relevant to add other technical standards to quality scope, such as the EN 13790-1/2 (CEN, 2003) for standardized inspection of sprayers.

Following logical steps, the next article to read states the link between the references and the tools needed:

“6.2.1 The inspection body shall have available, suitable and adequate facilities and equipment to permit all activities associated with the inspection activities […]”.

Considering the test method of the nozzles in the current Royal Decree (annexe 5, codes L2-L7), the NTB fulfils completely the requirements and is able to detect the wear rate given as tolerances (from 5% to 10%). The same exercise is done with the EN13790-1/2 which recommends the nozzles output measurement. The limit of 2.5% of inaccuracy of the measurement cited (article 5.2.5) gives the opportunity to objectify the metrological framework of the NTB. Trials with reference standards on the NTB were successfully done to validate this condition.

As obvious as it seems, this article also understands that some kind of specifications must be redacted by the technical team. It leads logically to the following article:

“6.2.4 All equipment having a significant influence on the results of the inspection shall be defined and, where appropriate, uniquely identified”.

Six NTB are used in Belgium. As they are sometimes transferred from a vehicle of inspection to another, a unique ID is given to each (sticker) to avoid any misunderstanding. The attribution of this ID creates automatically a whole “equipment file” where the first document recorded defines the equipment itself, with specifications cited before and further descriptions of the NTB acquired for the inspection. Calibration reports, calibration programme, calibration procedure and manuals will be added to complete the description of the equipment inside the quality system.

**Metrology**

One of the primordial aspects of the ISO 17020 standard is the metrology, treated in the chapter 6.2. It is in the nature of the ISO to give trust to inputs of the inspection process at the unique conditions that all the checks were done following its own directives, and that is why the calibration and the intermediate check of the equipment concern multiple articles. Only the most important articles will be discussed here.

First of all, the “brand new” nature of freshly acquired equipment is never a guarantee of quality from the ISO point of view:

“6.2.6 Where appropriate, measurement equipment having a significant influence on the results of the inspection shall be calibrated before being put into service, and thereafter calibrated according to an established programme.”

In fact, every important stage in the life of equipment (purchase, storage, repair, etc.) is
considered as a high risk situation by the ISO, mostly because of participation of outside influences (delivery services, visits, subcontracting, etc.). It is so considered that a calibration is inevitable to restore the confidence in the equipment. It is an important clarification in the case of NTB. They are long term equipment (some were put into service in 1995) more concerned by interventions due to their complex conception (repairs, update, etc.).

The following programme of calibration need more technical analysis and must consider quality of the equipment (is it fragile or naturally subject to deviation of measurements?) and intensity of use. The interval between two calibrations must assure a high confidence in results in normal conditions of use (no extreme events or accidents). For example, it was calculated that a NTB is used for 11 sprayer per day, with 36 nozzles each to test (average width of boom is around 18m) (Defays, 2015; Declercq, 2015), so up to 400 nozzles are tested every day of inspection by one NTB. The measuring time of each flow rate is approximately 3 seconds, that is to say 20 minutes of use per day. Monthly it represents nearly 7 hours of use. In conclusion, a monthly calibration of the NTB should give a high confidence in the measurement done during the month to come, considering that the components of the NTB are of an industrial type (non-stop use for long-term).

It is normal that such programme, firstly made on estimation, evolves with retrospection (after some time and analysis of the recordings) to find the right balance between the confidence and an acceptable amount of work and time in calibration.

All the work done in calibration and analysis is useless if the work is not done on solid foundation: “6.2.7 The overall programme of calibration of equipment shall be designed and operated so as to ensure that, wherever applicable, measurements made by the inspection body are traceable to national or international standards of measurement, […]”.

A NTB may be considered as a sum of sensors (pressure and flow rate) but the final output of the NTB is a measured flow rate and it is the parameter to calibrate. In consequence, the standards of measurement must be/produce a perfectly defined flow rate. ILVO produces such standards with an ISO 17025 certificate. One typical standard consists of a set of 4 nozzles of different size (orange, yellow, red, grey) browsing the range of measurement of the NTB flow meter. The Figure 3 presents an example of calibration report. The method is simple and consists in the comparison of the reference nozzle set values (given by the ISO 17025 certificate) and the measurements produced by the NTB for the same nozzle set. The conclusion of the calibration depends on the deviation after correction of each nozzle of the set.
NTB CALIBRATION REPORT

Date: 31/03/2014 Opérateur: L. Lor

Standard of measurement nozzle set at 3 bars (l/min)

<table>
<thead>
<tr>
<th>Set N°</th>
<th>Size and model</th>
<th>Mean</th>
<th>Std deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>TeeJet XR 80 01 VS orange</td>
<td>0.38</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Albuz API 110 02 yellow</td>
<td>0.769</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>TeeJet XR 80 04 VS red</td>
<td>1.589</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Albuz API 110 06 grey</td>
<td>2.375</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Flow rate of set measured at 3 bars on the NTB (l/min)

<table>
<thead>
<tr>
<th>Size and model</th>
<th>rep 1</th>
<th>rep 2</th>
<th>rep 3</th>
<th>Mean</th>
<th>Std deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TeeJet XR 80 01 VS orange</td>
<td>0.390</td>
<td>0.390</td>
<td>0.389</td>
<td>0.390</td>
<td>0.001</td>
</tr>
<tr>
<td>Albuz API 110 02 yellow</td>
<td>0.775</td>
<td>0.776</td>
<td>0.773</td>
<td>0.775</td>
<td>0.002</td>
</tr>
<tr>
<td>TeeJet XR 80 04 VS red</td>
<td>1.601</td>
<td>1.601</td>
<td>1.601</td>
<td>1.601</td>
<td>0.000</td>
</tr>
<tr>
<td>Albuz API 110 06 grey</td>
<td>2.363</td>
<td>2.368</td>
<td>2.369</td>
<td>2.360</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Regression coefficient

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.007171</td>
<td>-0.013950</td>
<td>0.999942</td>
</tr>
</tbody>
</table>

Line cutting Y axis at b

![Graph showing NTB flow rate vs. nozzle set flow rate] (Fig.3 Example of calibration report of a NTB, using a nozzle set with ISO 17025 certificate as measurement standard.

Concerning the accidents and extreme events or unpredictable dysfunction that can happen on a random basis, the ISO propose regular checks as a first defence line in-between two calibrations:
“6.2.9 Where relevant, equipment shall be subjected to in-service checks between regular recalibrations.”

“In-service” means that the check must be done in real conditions, most preferably during the inspections, to take into account all the parameters faced by the NTB during its activities. A check is not a calibration and can be resumed to the measurement of one nozzle of reference (not an international standard of measurement, reserved solely to calibration). A simple nozzle with a well determined flow rate (tested multiple times directly after calibration) is enough. It must be at the disposal of the inspection team and reserved for that specific check in the vehicle.

This simple action presents, fast and simple, presents multiple advantages:

- Give the assurance that the future inspections are still realised with enough confidence
- Detection of deviation, demonstrate the need to proceed a calibration.
- Reduce the number of inspections impacted if a deviation is detected. This point should not be underestimated: if a monthly calibration in the middle of the year shows deviation out of tolerance, the inspection authority must consider the risk that all the sprayers inspected in the past month can be subject to wrong measurements and conclusion (accepted/refused). The checks must be seen as an opportunity to avoid great problems (re-inspection below cost, discredit of inspection, extra work for the teams): the more checks are done between calibrations, the more the consequences of deviation will diminish.

Once again, an inspection team in Belgium inspects an average 11 sprayers/day. This amount is enough to justify a daily check of the NTB. The tolerance used for the check is still the one given by the EN13790-1 (2.5%).

To conclude this chapter, the article 6.2.3. of the ISO reminds the global politic of the metrology and the specifications of the NTB:

“6.2.3 The inspection body shall ensure the continued suitability of the facilities and the equipment mentioned […].”

Conclusions

Starting up certification demanded a big effort from the inspection authorities, but nowadays the quality assurance system is running with an acceptable amount of effort and time. Besides the extra work and costs, there are also advantages following out of the certification. The example of the integration of the nozzle test benches (NTB’s), for the metrological aspects, shows that the ISO 17020 helps to organize and secure the process of inspection. The current management of the NTB’s permits the Belgian inspection authorities to have high confidence in the results given.

References


Assessment of the traverse distribution measurement in the inspection of horizontal boom sprayers

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Summary

For the inspection of sprayers, the traverse distribution of horizontal booms can be measured in two ways according to the EN ISO 16122-2: 2015 standard, (i) nozzle flow rate and pressure distribution or (ii) spray distribution on a bench.

To assess the different standardized methodologies, measurements were carried out in the same boom with different models of flat fan nozzles, at different working pressures and boom heights. The results show that the measurements made according to the (i) methodology provide higher favourable inspection results. It was also shown that the nozzle size, the nozzle type (standard or air injection) and the boom height have a significant influence on the number of favourable results in the measurement of the traverse distribution according to the (ii) methodology. However, the variation of the working pressure does not significantly affect the measurement results.

It was also noticed that, in general, the traverse distribution requirement related with the coefficient of variation, is easier to meet than the requirement of a maximum deviation of the collected volume in each bench groove.

The new, shorter overlapping length defined in EN ISO 16122-2 causes a higher number of favourable results in comparison with the old standard, because of significantly better results for the deviation of the volume collected in each bench groove.

In a sprayer inspection, the boom traverse distribution is usually measured with a mobile bench designed according to EN ISO 16122-2. Inspection results obtained with such a bench are very similar to the results of a fixed bench built according to the ISO 5682-2:1997 standard. It was only noticed a higher number of favourable results with the mobile bench, when the boom was equipped with low flow rate (02, yellow) nozzles.

Results of this assessment should be taken into account in the inspection of horizontal boom sprayers and could also provide useful information when a revision of the inspection standard is made.

Keywords: sprayer inspection, horizontal boom, traverse distribution

Introduction

According to the annex II of the 2009/128/CE directive, the uniformity of the spray distribution has to be measured in a sprayer inspection. The harmonised standard EN ISO 16122-2:2015 for the inspection of the horizontal boom sprayers establishes the methodologies for the measurement of the uniformity of the traverse distribution.

The first possibility is to measure the flow rate of each nozzle, together with the pressure distribution in the sprayer boom. Flow rate measurements can be carried out with the nozzles mounted on the sprayer boom or dismounted using a purpose-built measure-
The standard requires that the accuracy of the measurement devices is higher than 2.5% of the measured value. The deviation between the measured and the nominal flow rate has to be lower than ±10% for each nozzle and the pressure drop in the sprayer boom has to be lower than 10% of the working pressure.

The second methodology is based on the measurement of the uniformity of the traverse distribution with a measuring bench that is built according to the requirements of the inspection standard. The bench has to collect the spray from the boom on 100-mm wide grooves. The coefficient of variation of the volumes collected by all the bench grooves along the overlapping length of the boom has to be lower than 10%. Besides, all the measured volume values have to be within the ±20% interval around the average volume.

In relation with the previous sprayer inspection standard, EN 13790-1:2004, the new standard has maintained the same methodology for the measurement of the traverse distribution, except for the definition of the overlapping length. In the new standard, the verification of the uniformity has to be carried out from the midpoint between the centre of the outermost nozzle and the centre of the penultimate nozzle on one side of the boom to the midpoint between the centre of the outermost nozzle and the centre of the penultimate nozzle on the other side of the boom.

The new inspection standard also establishes the requirements of the benches that can be used to measure the traverse distribution – i.e. minimum length, groove width accuracy, capacity and scale graduation of the graduated cylinders, measurement error, etc. Mobile electronic benches, which scan the spray distribution along the boom working in steps, are often used by the inspection workshops.

It is said that the two standardized methodologies for the measurement of the spray distribution don’t provide the same inspection results (Godyn et al. 2014). The objective of this work is to compare the spray distribution measurement results obtained with the use of both inspection methodologies. Besides, the effect of the new overlapping length and the accuracy or the mobile traverse distribution benches are also assessed.

**Methodology**

Different air-injection and standard flat fan nozzle models (table 1) where used for the measurement of the spray distribution uniformity. Three pressure values were selected within the working range of each nozzle. The actual pressure was always measured at the inlet of the horizontal boom and at the end of the three boom sections. Sixteen new nozzle units for each nozzle model and size (table 1) were mounted on the boom, with a separation between them of 50 cm. The overlapping length according to the EN 13790-1:2004 standard was 7.5 m, whereas taking into account the measurement requirements of the new EN ISO 16122-2:2015 standard, this length was reduced to 7.0 m.

Measurements were carried out with the boom placed at both 50 and 60 cm above a horizontal patternator (from now on referred as patternator), built according with the requirements of the ISO 5682-2:1997 standard (figure 1 left). The bench had a measuring surface of 2200x3000-mm and was equipped with 50-mm-wide grooves. The collected volume in each groove in a given time was measured with an electronic system and stored in a computer file. For each combination of nozzle, pressure and working height, measurements were carried in a two replication basis.
The corresponding flow rate measurements for each single nozzle were carried out on a bench equipped with an electromagnetic flowmeter and a pressure gauge (figure 1 right). The three working pressures for each nozzle model and size were the same as those used for the measurement of the traverse distribution uniformity (table 1). Two replicates of each measurement were also carried out.

Finally, the traverse distribution uniformity with the same nozzles was measured using a scanner test bench according to EN ISO 16122-2:2005 (from now on spray scanner), as it is shown in figure 2. The bench is mounted on a railway that can be set up on levelled ground. It had a measuring surface of 800x1500 mm and it was controlled by wireless communication from a computer with the corresponding software. In this case, only the central pressure of the three selected in the previous measurements (last column of table 1) was used in each kind of nozzle, and the boom was only placed at 50 cm above the bench. All the measurements were also repeated twice.

**Tab. 1 Working pressures for the different flat fan nozzle models used in the tests.**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Nozzle model and size</th>
<th>Pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albuz</td>
<td>API 110 02, 03, 04</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>AVI 110 02, 03, 04(1)</td>
<td>3, 5, 7</td>
</tr>
<tr>
<td>Teejet</td>
<td>XR 110 02, 03, 04 VS</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>Hardi</td>
<td>F 110 02, 03, 04</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>INJET 02, 03, 04(1)</td>
<td>3, 6, 8</td>
</tr>
<tr>
<td>Lechler</td>
<td>IDK 120 02, 03, 04(1)</td>
<td>2, 4, 6</td>
</tr>
</tbody>
</table>

(1)Air-injection nozzles

**Fig.1** Horizontal patternator for the measurement of the traverse distribution uniformity (left) and nozzle flow rate bench

**Fig.2** Mobile spray scanner for the measurement of the traverse distribution of a horizontal boom
Results and discussion

For every traverse distribution measurement made with the patternator or the spray scanner, the values of the coefficient of variation (CV, %) and the deviation (D, %) of each measured volume from the mean value were computed, as indicated in the EN ISO 16122-2:2015 standard. Besides, the deviation between the measured and the nominal flow rate of every nozzle was also determined, as it was the pressure drop in the spray boom.

Generalized linear models were used for the statistical analysis of the results. The experiment was carried out following a factorial design: kind of nozzle (standard/air injection) x nozzle size (02/03/04) x boom height (50/60 cm). CV values were considered normally distributed. For the result of the sprayer inspection, according to both the CV and D values, a binomial distribution was considered (favorable inspection=1 or unfavorable inspection=0). Statistical model calculations were made with the R software.

Comparison between the two standardized methodologies for the measurement of the traverse distribution

A clear difference is seen between the inspection results obtained with the two methodologies. If the traverse distribution is determined by the measurement of the nozzle flow rate and the pressure drop in the boom, in all the cases the results of the inspection are favorable. The measured flow rates are within the ±10% interval around the nominal flow rate for every single nozzle. Besides, the pressure drop in the horizontal boom, where the nozzles were mounted, is very low, well within the -10% maximum variation required by the inspection standard.

However, if the traverse distribution is measured by the patternator, the values of the CV and of the deviation from the mean volume made that the inspection results are not always favorable. This is the case either if the overlapping length of the boom is defined according to the EN 13790-1 or to the EN-ISO 16122-2 standard, although the number of the favorable results is not the same (tables 2 and 3).

It is noticed that the volume deviation (D) requirement for the traverse distribution is more difficult to meet than the CV requirement. In some spray distribution measurements, the value of the CV is less than 10%, but one or more measured volumes deviate more than ±20% of the average value.

If only the CV values are taken into account, no significant differences are found between the inspection results obtained according the old or the new inspection standard. Nevertheless, if the D values are considered, the number of favorable inspection results significantly increases if the overlapping length is defined according to the new inspection standard.

The nozzle working pressure has got no significant effect on the number of favorable inspection results. The fact that the working pressure does not affect the inspection result, as long as it is kept within the working range for each kind of nozzle, makes easier to carry out the inspection.

On the other hand, the kind of nozzle (standard or air-injection), the nozzle size and the boom height, are all significant. They have an influence on the inspection results related to the volume deviation (D), but not to the CV. If standard flat fan nozzles are used, the number of favorable results is lower in comparison with air-injection nozzles. The same happens if small nozzles (02) are used, instead of bigger ones (03 and 04). According to
these results, nozzles with smaller droplets produce a less uniform spray distribution.

In relation to the boom height, better distribution uniformity is obtained with the boom placed 50 cm above the patternator, although this effect is no more noticed if the overlapping length of the boom was reduced according to the EN-ISO 16122-2:2015 standard.

**Tab. 2 Number of favorable inspection results according to the coefficient of variation (CV) requirement when measurements are carried out following the old inspection standard (EN 13790-1:2004) or the new one (EN ISO 16122-2:2015). Values followed by the same letter within the same row and factor are non-significant (p<0.01)**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Kind of nozzle</th>
<th>Working height (cm)</th>
<th>Nozzle size</th>
<th>Pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Air-injection</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>02 (yellow)</td>
<td>03 (blue)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>04 (red)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Fav. (13790)</td>
<td>97a</td>
<td>106a</td>
<td>69a</td>
<td>72a</td>
</tr>
<tr>
<td></td>
<td>61a</td>
<td>72a</td>
<td>72a</td>
<td>70a</td>
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<tr>
<td></td>
<td>69a</td>
<td>66a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fav. (16122)</td>
<td>100a</td>
<td>106a</td>
<td>72a</td>
<td>72a</td>
</tr>
<tr>
<td></td>
<td>64a</td>
<td>72a</td>
<td>72a</td>
<td>70a</td>
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<td>72</td>
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</tr>
<tr>
<td>measurements</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Tab. 3 Number of favorable inspection results according to the deviation from the mean volume (D) requirement when measurements are carried out following the old inspection standard (EN 13790-1:2004) or the new one (EN ISO 16122-2:2015). Values followed by the same letter within the same row and factor are non-significant (p<0.01)**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Kind of nozzle</th>
<th>Working height (cm)</th>
<th>Nozzle size</th>
<th>Pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Air-injection</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>02 (yellow)</td>
<td>03 (blue)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>04 (red)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Fav. (13790)</td>
<td>43a</td>
<td>77a</td>
<td>50b</td>
<td>20a</td>
</tr>
<tr>
<td></td>
<td>53b</td>
<td>47a</td>
<td>38a</td>
<td></td>
</tr>
<tr>
<td>Fav. (16122)</td>
<td>65a</td>
<td>83a</td>
<td>78a</td>
<td>33a</td>
</tr>
<tr>
<td></td>
<td>62b</td>
<td>57a</td>
<td>52a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>66b</td>
<td>52a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of total</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>72</td>
</tr>
<tr>
<td>measurements</td>
<td></td>
<td></td>
<td></td>
<td>72</td>
</tr>
</tbody>
</table>

**Assessment of a mobile spray scanner bench for the measurement of the traverse distribution uniformity**

The CV values obtained with the mobile spray scanner (figure 3) are slightly higher than the values obtained with the patternator (table 4) but the difference is non-significant. In relation with the inspection result assessment, the number of favorable results is higher when measurements are carried out with the sprayer scanner. The difference
is due to the significantly higher number of favorable results that were found in the smallest size nozzles (table 5), but only when the deviation from the mean volume (D) requirement was taken into account. On the other hand, the number of favorable results when only the CV requirement was considered was exactly the same with the two kinds of benches (table 6).

**Tab. 4** *Mean coefficient of variation values (%) from the traverse distribution measurements made with the patternator and the spray scanner. Differences between measured values are always non-significant (p<0.01)*

<table>
<thead>
<tr>
<th>Kind of nozzle</th>
<th>Nozzle size</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>02 (yellow)</td>
<td>6,6</td>
</tr>
<tr>
<td>Air-injection</td>
<td>03 (blue)</td>
<td>4,6</td>
</tr>
<tr>
<td>Air-injection</td>
<td>04 (red)</td>
<td>5,5</td>
</tr>
<tr>
<td>Spray scanner</td>
<td>02 (yellow)</td>
<td>7,0</td>
</tr>
<tr>
<td>Air-injection</td>
<td>03 (blue)</td>
<td>5,4</td>
</tr>
<tr>
<td>Air-injection</td>
<td>04 (red)</td>
<td>6,2</td>
</tr>
</tbody>
</table>

**Tab. 5** *Number of favorable inspection results obtained with the patternator and the spray scanner according to the volume deviation (D) requirement. (*)Differences between measured values are significant (p<0.01)*

<table>
<thead>
<tr>
<th>Kind of nozzle</th>
<th>Nozzle size</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>02 (yellow)</td>
<td>12</td>
</tr>
<tr>
<td>Air-injection</td>
<td>03 (blue)</td>
<td>16</td>
</tr>
<tr>
<td>Air-injection</td>
<td>04 (red)</td>
<td>11</td>
</tr>
<tr>
<td>Spray scanner</td>
<td>02 (yellow)</td>
<td>12</td>
</tr>
<tr>
<td>Air-injection</td>
<td>03 (blue)</td>
<td>18</td>
</tr>
<tr>
<td>Air-injection</td>
<td>04 (red)</td>
<td>10</td>
</tr>
<tr>
<td>Total number of measurements</td>
<td>18</td>
<td>18</td>
</tr>
</tbody>
</table>

**Conclusions**

According to the measurements, the two standardized methodologies for the measurement of the traverse distribution uniformity in a horizontal boom inspection do not provide the same results.

The standard requirements are more difficult to meet when distribution uniformity measurements are carried out using a horizontal patternator (fixed or mobile).
Mobile spray scanners built according to the inspection standard design requirements are reliable benches for the use in sprayer inspections, since the results are similar with those obtained with a fixed laboratory patternator.

In any case, the deviation from the mean volume requirement is more restrictive than the requirement based on the coefficient of variation. Wherever the deviation for any measured volume was lower than ±20%, the value of the coefficient of variation was less than 10%, but the opposite was not always true.

Results also show the effect of the spray boom working conditions on the inspection. It is interesting to highlight that the nozzle working pressure does not influence the result of the inspection, as long as it is kept within the working range for each kind of nozzle.

The results of this assessment should be taken into account in the inspection of horizontal boom sprayers and could also provide useful information when a revision of the inspection standard is made.

**Tab. 6 Number of favorable inspection results obtained with the patternator and the spray scanner according to the coefficient of variation deviation from the mean volume requirement**

<table>
<thead>
<tr>
<th>Kind of nozzle</th>
<th>Nozzle size</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>02 (yellow)</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>03 (blue)</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>04 (red)</td>
<td>12</td>
</tr>
<tr>
<td>Air-injection</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

**References**

Session 5

Harmonise the training of the inspectors to achieve the same professional level of the inspections

International training courses on inspection and calibration of pesticide application equipment. A European Commission Directorate General for Health and Food Safety initiative

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² University of Turin – DiSAFA (Italy)
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Training and knowledge represents, whatever the activity is, one of the most important aspects affecting the process success. These aspects became mandatory for all the stakeholders involved in the management of pesticide since the publication of Sustainable Use Directive (SUD). Six years after, the Member States have got proper training and done a lot of work, although much more efforts have to be made in this subject (DG SANTE, 2014a). The Consumers, Health, Agriculture and Food Executive Agency (CHAFEA), under the Directorate General for Health and Food Safety (DG SANTE), launched in 2014 an official tender within the Better Training for Safer Food (BTSF) programme focused in the very specific subject of inspection and calibration of pesticide application equipment in professional way. Two years after, five three days training courses have been already arranged and 95 participants from 28 countries have been trained. The organization of the courses has been arranged by a consortium created by AINIA (Spain), UPC (Spain) and AETS (France) and the courses have been delivered at three of the most representative laboratories in Europe: Unit of Agricultural Machinery at Politechnic University of Catalonia (UPC), DiSAFA at University of Turin and Julius Kühn Institute in Germany. An overview of the information obtained before, during and after the training courses indicates that, in general, knowledge on technical aspects related with inspections and calibration differs among the MS responsible for implementation of SUD; differences among MS in expertise, organization of mandatory inspections, training activities, etc. are also evident. The practical activities which are part of the BTSF courses have been very well appreciated among the participants and, in general, close to 100% of the participants indicated that those kind of trainings are important to guarantee the implementation of SUD in the EU.

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

Introduction

The inspection of sprayers in use in all EU Member States (MS) became mandatory after the publication of the European Directive 2009/128/CE for a Sustainable Use of Pesticides (European Union, 2009a). 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, Gil and Gracia, 2004).
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 publication of the Sustainable Use Directive (EU Directive 128/2009/CE) six years ago was the official starting point for a large series of mandatory actions to be arranged in all MS in order to achieve an efficient and sustainable use of pesticides. For the first time, several official documents were pointed on the use-phase of Plant Protection Products (PPP) and aspects as inspection of sprayers in use, the recently enforced Integrated Pest Management or the basis for a complete and efficient training program for professional users, have been included in the European legislation.

Since the publication of SUD in addition, a large number of official documents, international standards, local and/or regional legislations have been developed, as the new international standards for inspection of sprayers in use as ISO 16122-series (ISO 2015), and the amending of the Directive 2006/42/CE with regard to machinery for pesticide application (European Union, 2009b). Important and most of them mandatory documents that should be widely known by the users (farmers, manufacturers, advisors…).

Training has become one of the most valuable actions and one of the most appreciated among the stakeholders (Gil and Gracia, 2004) and equally important as technical aspects (Doruchowski et al., 2014). According to the SUD “professional users shall conduct regular calibrations and technical checks of the pesticide application equipment in accordance with the appropriate training received”. It means that aspects related with nozzle selection, volume rate calculation and pressure adjustment, among others, must be well known parameters to achieve an accurate PPP use. Considering new sprayers, professionals should be able to request at sprayer’s dealers all the mandatory requirements that a new sprayer should accomplish prior its placement into the market. Even more, sprayer’s manufacturers should be able to apply the European requirements in all their sprayers, avoiding future problems. But unfortunately this is not the case in most of the cases. Lack of training among farmers, greater than expected ignorance about official requirements and difficulties in the extension process makes difficult to guarantee a safe, economic and sustainable use of pesticides.

The objective of this text is to provide an overall resume after the organization of five international training courses focused on inspection and calibration of pesticide application equipment. Those courses have been organized in the frame of an International training activity promoted by the European Commission (DG SANTE).

Specific BTSF training actions promoted by DG SANTE on inspection and calibration

Production of food in a safe and sustainable way has become since years one of the most important goals. Customers, producers, retailers and governments must accomplish this fundamental objective. For this purpose several actions (private or public) have been established. Since Global-GAP production schemes, official control of MRL and very restrictive legislation concerning the allowed active ingredients, in the last years it has been a wide activity focused on food quality. The European Commission via its General Directorate for Food and Health Safety (DG SANTE) aims at making Europe a healthier, safer place, where citizens can be confident that their interests are protected. Among other activities, DG SANTE is focused in the safe and sustainable use of pesticides, due their
close relationship with food safety. For that reason, DG SANTE promotes and finances a series of training activities regarding this topic. One of the recently established actions has been a series of international training courses under Better Training for Safer Food (BTSF) programme. A clear link between spray technology and food safety can be underlined after reading the title of the call: Organisation and implementation of training activities on inspection and calibration of pesticide application equipment in professional use (CHAFEA/2014/BTSF/02) (DG SANTE, 2014b). The main objective of this series of three days training courses is training the staff of competent authorities and other stakeholders in order to keep them updated with the aspects of EU law in the area of inspection and calibration of pesticide application equipment (PAE), being able to achieve a harmonized, objective and adequate process in all MS. Additionally, it is intended to spread this activity among other countries outside EU, as relevant food suppliers to the EU. A detailed look at the specific objectives of this activity indicates the great interest on guarantee an accurate and precise knowledge not only in legal and administrative aspects concerning pesticide use but also technical aspects and practical requirements concerning spray application techniques. It must be remarked that the target group of these courses is official bodies of all EU members in charge of development and application of new European legislation:

- Ensure a harmonized, practical and suitable training process for staff in charge of the organization of inspector’s training activities in Europe.
- Accomplish with the received mandate from European Commission in the sense of be ready to inspect all type of PAE, giving a training contents of all type of PAE suitable to be inspected.
- Keep participants updated with the latest developments or developments in the spray application technologies.
- Propose the requested knowledge and methods so that the staff in charge may guarantee a stand level of quality, not only during the training activities but also during the inspection procedure itself.
- Give main directions and clear processes about the important aspects of calibration and maintenance of PAEs.

Methodology
The BTSF-training covered the main aspects related with the mandatory inspection of sprayers in use in EU and also the important aspect related with calibration of the sprayers. Taking into account the SUD provisions, topics as official procedure of the inspections, the situation of new ISO standards, administrative procedure, technical requirements and differences among EU members were addressed during the three days courses. Linked to that, and also following the SUD requirement concerning calibration of sprayers, aspects as nozzle selection process, determination of the optimal volume rate, drift reduction and good agricultural practices were included. Precision agriculture was also included as a part of the program, giving to the participants some guidelines about the state of the art and possibilities of the use of new technologies to improve the pesticide application process. The training program was organized in a logical order combining administrative, technical and practical aspects. Workshops, discussion sessions and case studies were selected and programmed to make more attractive and profitable the course for the participants. Time distribution and activities were carefully distributed (Figure 1).
The programme of the Trainings was organized on in two half days and two full days, and it includes tutors’ presentations, working groups and discussions. The programme was designed considering relevant pedagogical aspects as:

- Well balanced theory and practical (workshops, case studies,..) activities
- Topics organized in a logical sequence
- Tutor’s skills according to assigned topics
- Time distribution aligned with interest and importance of the topics
- Balanced time distribution among tutors

**Fig. 1** Time Distribution top) and activities (bottom) during the training courses
• Training activities were completed with the organization of discussion sessions and a large list of questions that tutors included during their lectures, in order to start debates over interesting common subjects among participants.

Results
Five over six training courses have been already organized. First objective information concerns the number and origin of participants. According the data (Figure 2) 95 participants from 28 different countries, both EU members and non-EU followed the training course. It is also important to remark that most of the participants to the training courses (61.1%) represented their official statement of government. The rest of participants represented local authorities of different MS, researchers, technicians and also inspectors of sprayers (Figure 3).

Fig. 2 Distribution of 95 participants to the training courses

Results obtained from the mandatory survey arranged after every training course revealed a great opinion concerning not only technical aspects and contents of the training course, but also about logistical and organization aspects (Table 1). Technical contents of the training sessions (4.81/5) and course materials (4.75/5) have been the two aspects with the highest score. Concerning practical aspects, it must be mentioned that networking and exchange experience with other colleagues was the most appreciated aspect.
**Fig. 3** Different background and expertise of the participants to the training courses

Expertise, skills and training capabilities of all the tutors were also evaluated after training. Aspects as clarity of presentations and interactivity were quantified. Results obtained indicated that, in average, those parameters were very well appreciated with scores of 4.67/5 and 4.72/5, respectively.

**Tab 1** Results of the survey (values over 5.0) concerning technical and organizational aspects of the training courses (n=95)

<table>
<thead>
<tr>
<th>Technical coverage</th>
<th>Value</th>
<th>Organization</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical contents</td>
<td>4.81</td>
<td>Catering (meals and others)</td>
<td>4.59</td>
</tr>
<tr>
<td>Relevance with daily work</td>
<td>4.59</td>
<td>Travel arrangements</td>
<td>4.50</td>
</tr>
<tr>
<td>Balance practices and theory</td>
<td>4.69</td>
<td>Conference venue /room</td>
<td>4.73</td>
</tr>
<tr>
<td>Course materials</td>
<td>4.75</td>
<td>Social event</td>
<td>4.69</td>
</tr>
<tr>
<td>Helpful to everyday work</td>
<td>4.69</td>
<td>Networking</td>
<td>4.77</td>
</tr>
<tr>
<td>Average</td>
<td>4.73</td>
<td>Average</td>
<td>4.64</td>
</tr>
</tbody>
</table>

**Conclusions and remarks**

After 5 training courses, including 95 participants from 28 different MS, several conclusions can be addressed:

Training represents a key factor to guarantee the success of the implementation of SUD, especially with all aspects related with inspection and calibration of pesticide application equipment.
The balanced combination between theory and practical activities has been very well appreciated for the participants. In most of the cases, comments have been addressed in the sense to increase the number of practical hours.

It has been a common opinion of the participants the fact that too many items have been included in the three days program, which reduce the time for a hypothetical extension of practical activities.

Networking, exchange of opinion and experiences has been very well appreciated for the participants.

Great differences in terms of expertise and technical knowledge have been detected among participants. Those differences can be extrapolated also to the different countries, with important differences in background, experience and organization.

That kind of actions represents one of the most profitable tools to improve the phase use of plant protection products.

References


ISO 2015. Agricultural and forest machinery – Inspection of sprayers in use. Parts 1, 2 & 3.

SPISE Advice on main training topics for basic and refreshment courses

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Introduction

The Article 8 of the EU Directive 128/2009/EC foresees that Member States shall ensure that pesticide application equipment (PAE) in professional use shall be subject to inspections at regular intervals. Each Member State shall establish certificate systems designed to allow the verification of inspections and recognize the certificates granted in other Member States. One of the prerequisite for such mutual recognition of inspections is a minimum specification for a training of inspectors.

At the SPISE workshops in 2012 and 2014 were presented surveys on how training courses of sprayer inspectors are performed throughout Europe. At that time the training has considered national testing protocols or inspection according to the norm EN 13790. Course length, course content and examination procedures varies between countries. This can be explained by some different factors; the basic training or professional education of the staff that shall be trained in inspection of PAE varies. Some countries have an education of mechanic for agricultural machinery – in other countries such training does not exist. The purpose of the inspection of PAE varies, countries may focus on inspection of the sprayer or inspection combined with advising the owner, repairs, upgrading, calibration or adjustment of the equipment.

A result of SPISE workshops has been that it has not been considered possible to give recommendations for a common course plan or course length. However, the analysis shows that main part of countries has basic training courses of 3-4 days combined with exams that are a combination of written and oral exams sometimes with performance of a complete inspection. Trainings are performed by authorities, universities, institutes or staff with some national approvals.

Additional to the basic training courses several countries have regular refresher training. The time intervals vary between annual to five years. In the perspectives that several countries have no previous activities in inspection of PAE and that recently new standards for inspection of sprayers in use are published, EN ISO 16122 – series, there is a need for information on the aspects of training of inspectors.

Based on discussions in SPISE workshops and work in SPISE TWG, SPISE TWG 5 has developed SPISE Advice to identify topics that may be considered as relevant in examination and the training of Inspectors of PAE. It is expressed in general terms to be applicable in all situations independent on kinds of equipment, local regulation etc.

Baseline for inspector’s knowledge

Criteria for the basic knowledge of inspectors of PAE exist in different countries. Essential parts are listed below as SPISE proposals on demands on inspector’s knowledge:

The inspector shall:

- have participated and be approved in a recognized training course
- have knowledge of the organizational aspects of inspection and testing procedure
Examination content in basic courses

An examination of the participants in training courses is necessary to assure that the inspectors have sufficient knowledge. The examination shall verify the level of knowledge. This knowledge can be achieved independently from course length or course content, depending on the local required background education or training. SPISE TWG has identified topics that can be relevant to assure the same level of knowledge between countries.

An official exam comprising questions from the proposed topics for exam should be arranged. Preferable is combined exams, including theoretical questions (oral/written) with practical exercises (a complete inspection of at least 1 equipment of relevant type). Examinations should preferably be done by third party or, if the training staff also perform the examination, under supervision of the organisation or authority responsible for authorisation of inspectors.

The proposed head topics to be considered in examination

- Environmental-, technical and biological background motives for inspection
- Basic knowledge on PAE
- Health and safety for inspection staff
- General and local legislation and administrative procedures:
- training and approval procedure of inspectors
- approvals of workshops
- procedure for reporting of result of inspection
- Requirements on inspection site
- Requirements on test equipment and calibration of test equipment
- The inspection of PAE:
- requirements on PAE
- test methods
• use of test equipment
• The practical inspection on PAE
• Identifying defects on PAE
• advise how to repair defects or upgrading of the equipment

Additional topics when the inspection may be combined with adjustments and calibration
• Knowledge in practical use of PAE e.g. spraying including nozzle choice advising, new technologies, identifying Drift Reducing Technologies,
• Calibration of PAE, adjustment, nozzle selection

Basic course
The length of basic training course, the course content and the relative size of the different topics, could vary depending on national or local situation, depending on e.g. dominating crops or types of used equipment. Course length and emphasis on different topics is also depending of the background training of the staff. A general recommendation would be a course-length on 3-4 days. The SPISE Advice proposes topics that may be relevant. The content should reflect the needs according to the requirements in the examination.

The proposed topics can be considered as “modules” connected to relevant parts of the training. They have no priority order and do not specify details about the content, only the topics and subtopics that may be relevant in the basic courses.

Trainers competence
The involved trainers should have a high knowledge and experience in the topics. The training should be done to assure that inspectors are trained independent of market situations regarding PAE and testing equipment and to be able to execute inspections in a correct and independent manner.

Theory and practices
The length of the course should be dedicated to include theoretical and practical activities to assure that participants are familiar with the topics, the inspection procedure and the test equipment.

Training course topics/course modules
• Environmental- technical and biological motives for inspection
  - Risks for pollution of water courses and other surrounding environment
  - e.g. point sources, drift, overdosing
  - Distribution influence on applied dose
  - Used amount of PPP
  - Risks for residues in food
  - Risks for environment eg drift, overdosing
• Basic knowledge on PAE
  - Basic on machines working principles
- Influence of different parts on the equipments working mode and results
- Defects influence on environment and biological results

• General and local legislation and administrative procedures:
  - training and approval procedure of inspectors
  - approvals of workshops
  - bureaucratic procedure for reporting of result of inspection
  - Requirements on inspection site
  - Requirements on test equipment and calibration of test equipment
  - National quality control or certification system for the workshops and inspections

• The inspection of PAE:
  - requirements on PAE in inspection
  - test methods
  - available test equipment
  - use of test equipment
  - test report and reporting (protocols, stickers, etc)

• Theory and practice on inspection of different equipment/modules

Emphasis on equipment due to national or local conditions depending on which kind of equipment is mainly used. E.g.:
  - Boom-sprayers
  - Sprayers for bush and tree crops
  - Fixed and semi-mobile sprayers.
  - Seed-treatment equipment
  - Knapsack sprayers
  - Granular spreaders
  - Etc…

• Health and safety for inspection staff
  - Importance of clean working conditions
  - Risks for test operators
  - Relevant personal protective equipment

• Test equipment and calibration of test equipment
  - Relevant available test equipments

• Procedures for regular calibration or official control of test equipment

• Evaluation of course

Additional in case the inspection may be combined with adjustments and calibration

• Knowledge in pesticide application including e.g. nozzle choice advising, new technologies and identifying drift reducing technique
Calibration of PAE, nozzle selection e.g. l/area unit depending on forward speed and nozzle flow.

Adjustment of the equipment to crop e.g. water volumes, nozzle types, adjustment of air settings to crop type or crop development stage.

**Refresher course**

According to SPISE surveys, refresher courses are arranged in several countries at regular intervals. The courses are arranged as a supplement to other contacts between the supervising organisation or authority and workshops and inspectors. Intervals vary, but two to three years are common. Except for the regular intervals, courses are arranged due to special reasons e.g. introduction of new standards or guidelines for inspection of additional types of equipment. Information is given about news in regulations, standards, test methods and test equipment. News on the market regarding PAE or components is transferred. In order to assure a harmonised performance of the inspection it may be relevant to repeat regulations and test procedures.

The refresher course is also a valuable forum for inspectors to meet and exchange experiences. The two-way communication between the responsible organisation or authority and the inspectors and workshops has shown to be fruitful.

Discussions about detailed problems in the test procedure or on certain equipment may result in needs to define advice or changes in regulations.

**Course Topics**

- Inspectors experiences:
- Reporting, test equipment, test procedures, special problems
- News on regulations, test procedure, test equipment, reporting system
- News on PAE market:
  - Machine types, e.g. sprayer models, nozzles
- Refreshing on
  - Regulations
  - Test procedure
  - Test equipment
  - Test protocol
  - Reporting of inspection
- When needed. Second day or additional day
  - Detailed training for additional PAE depending on local needs or new available methods, e.g.
  - Fixed and semimobile sprayers
  - Granular spreaders
  - Railways sprayers
  - Aerial spraying
  - Seed treatment
• Test methods and requirements
  - Theory and practicals
• System for reporting to authorities

Training material and detailed course plans
The detailed content of the course topics/course modules vary after local situation and local practices and is not further described here. In order to assist members states in the development of national regulations and training systems, SPISE TWG have collected training material and course-plans from a number of countries. These materials are made available at SPISE website.

Additional to the collected training material, SPISE Technical Working Group has developed a series of SPISE Advise that give detailed recommendations on inspection of various types of equipment, calibration and adjustments of equipment and quality assurance of inspection workshops.

These materials should be seen as examples on how different parts of the inspectors training can be executed. The approach varies depending on background training of the staff, how the training is done and also on how the inspection of PAE will be organised.

The SPISE Advices and training-material can be downloaded from the SPISE website at http://spise.jki.bund.de/
Session 6

Present experiences and problems in inspections activities

Self-inspection of spraying equipment not covered by official inspection system in Poland

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Summary

By way of derogation MS could exempt from inspection handheld or knapsack sprayers. In such case the operators should have been trained for the proper use of the sprayers (SUD art. 8.3.b). In Poland the hand-held and knapsack sprayers have been excluded from official sprayers inspection by decision of the Ministry of Agriculture, taken after a risk assessment for human health and the environment, based on the ordered research and report made by InHort Skierniewice (presented at SPISE 4). After excluding from inspection, the need of self-inspection exists. Therefore two instruction manuals describing the procedure of self-inspection of that kind of equipment were elaborated. They are to be used by the trainers providing trainings for the applicators and by the applicators themselves to perform the self-inspections of their equipment. The procedures were elaborated in form of the checklist questions. The instruction manuals are followed by training materials - an illuminated 80-page brochure. The brochure contains some basic information on knapsack sprayers and their professional use as well as relevant legislation and standards. Furthermore, the construction, mode of operation as well as frequent faults and basic repairs are also included and illustrated by photos. The brochure “Samodzielna kontrola opryskiwaczy” has been published at MA and InHort webpages: minrol.gov.pl and inhort.pl.

Keywords: self-inspection, excluded sprayers, handheld sprayer, knapsack sprayers

Introduction

The Sustainable Use Directive (2009/128/EU) in Article 8 (Inspection of equipment in use) says that “Member States shall ensure that pesticide application equipment in professional use shall be subject to inspections at regular intervals. The interval between inspections shall not exceed five years until 2020 and shall not exceed three years thereafter”. After 14 December 2016 the pesticide application equipment (PAE), being in professional use, have to be positively inspected at least once. “By way of derogation … following a risk assessment for human health and the environment including an assessment of the scale of the use of the equipment, Member States may … exempt from inspection handheld pesticide application equipment or knapsack sprayers. In this case the Member States shall ensure that operators have been informed of the need to change regularly the accessories, of the specific risks linked to that equipment, and that operators are trained for the proper use of that application equipment … in accordance with Article 5”. In article 5 (on training) it is stated that “Member States shall ensure that all professional users, distributors and advisors have access to appropriate training by bodies designated by the competent authorities”. 
In Poland the hand-held and knapsack sprayers have been excluded from official sprayers inspection by decision of the Ministry of Agriculture, taken after a risk assessment for human health and the environment, based on the ordered research and report made by Institute of Horticulture, Skierniewice (presented at SPISE 4). After excluding from inspection, the need of self-inspection exists. To help the trainers and the growers or applicators, the Ministry of Agriculture ordered the training materials on hand-held and knapsack sprayers self-inspection. The materials were elaborated in The Research Institute of Horticulture Department of Agro-Engineering in Skierniewice in the frame of Multi-annual Programme realised for and financed by Polish Ministry of Agriculture and Rural Development. Two instruction manuals describing the procedure of self-inspection of that kind of equipment were elaborated. They are to be used by the trainers providing trainings for the applicants and by the applicators themselves to perform the self-inspections of their equipment.

In Poland, the trainings on pesticide use may be carried out by persons with proper competences, using proper PPE and PAE’s and carrying out the trainings according to training programmes listed in the Ministry of Agriculture Regulation (Journal of Laws from 10 of May 2013; item no 554).

**Materials and methods**

In this paper three elements which may be used as a training materials are described: self-inspection procedures, inspection protocol and illustrated brochure. Two procedures of self-inspection of hand-held and of knapsack sprayers were elaborated in form of questions checklist and short descriptions of inspection procedures. Then the simple instruction manuals were elaborated, containing:

- checklist questions,
- description of the control procedure for each question,
- protocol of self-inspection of hand-held and knapsack sprayers,

The procedures were published on the web on InHort and Ministry of Agriculture webpages as a pdf files. Because it is open and free use, it is easy to extract the text and elaborate own PowerPoint presentation or other type of training materials. After the procedures were elaborated, basing on that, the photographs were taken to illustrate each inspection procedure. During the photographic session three types of lever-operated knapsack sprayers, one type of engine-driven knapsack sprayer and two types of hand-held sprayers were used. The selected photographic database containing ca. 600 of photos was then ready to illuminate the brochure, elaborated as the training material. Finally about 130 photos were used in the brochure. The illuminated 80-page brochure was elaborated to be used by trainers as training materials or by knapsack or hand-held sprayers users themselves.

**The check list Questions**

The questions and control procedures were elaborated being inspired by two standards concerning knapsack sprayers (being under development: ISO/CD 19932-3 and published: ISO 19932-2:2013). There are two types of questions in the procedure:

- on (device) presence,
- on (device) condition-functioning.
Therefore two types of answers are possible: one concerns the presence/absence of the device or solution e.g. “Is there the device present on the sprayer?” possible answers: Present or Not and another one, on the condition/functioning of the device fitted on the sprayer e.g. “Is it in good condition?” or “Does it work properly?” possible answers: Yes or No. Therefore there are two double columns for answers in the protocol with empty place for checking the answers. The information on inspection methodology of inspection and limit values is included in the self-inspection procedure or in the brochure texts. Some questions are single question ones and some are two sub-questions ones. In the second case each of sub-questions is speared by uppercase letter “AND” e.g.: “Is the quick-release mechanism present AND is it possible to open it under load and release the sprayer using only one hand?” or “Is there a pressure indicator present AND has it a recommended accuracy of indications?”.

The questions were arbitrary divided in two groups:

- questions that all should be answered positively in 100% - marked below by (100%),
- questions that may be answered positively in 80%.

Self-inspection questions for all types of hand-held and knapsack sprayers:

- Is the sprayer clean, empty and not pressurised?
- May the sprayer be carried by operator in vertical position by handle or shoulder strap?
- Is the operator able to wear the sprayer on his back comfortably and safely without aid?
- Is the quick-release mechanism present AND is it possible to open it under load and release the sprayer using only one hand?
- Are the load bearing straps present (wider or softly upholstered elements of harness)?
- Is the nominal volume of spray tank clearly marked?
- May the sprayer, filled with water to the nominal volume, stand upright on flat hard surface without support? (100%)
- Is the sprayer, filled with water to its nominal volume, when not pressurised, standing on the ground vertically and inclined at 45° (strap side facing down and up) not leaking? (100%)
- Is the sprayer, filled with water to its nominal volume, when not pressurised, during wearing it on operator’s back not leaking? (100%)
- Is the sprayer, filled with water to its nominal volume, being under the maximum pressure, not leaking when not spraying? (100%)
- Is the sprayer filled with water to its nominal volume, being under the maximum pressure, not leaking when spraying? (100%)
- Is the strainer/filter present in the tank opening AND is it in good condition?
- Is there a quick-acting shut off device present AND does it work properly?
- Is there a pressure regulator or other device present AND is it in good condition?
- Is there a pressure indicator present AND has it a recommended accuracy of indications?
- Are all hoses in good condition?
- Are all hoses tight connected? (100%)
- Are all flexible hoses laid without unnecessary stress and bends?
- Is there a filter fitted on the pressure side present AND is it in a good condition?
- Are the filter orifices less than the nozzles ones (Does filter mesh correspond to nozzle)?
- Are all nozzles fitted in the lance in good condition? (100%)
- Are all nozzle bodies in good condition?
- Is the shape of the spray jet regular (uniform shape, homogeneous spray)? (100%)
- Is the sprayer lever-operated AND is lever in good condition?

Self-inspection additional questions for engine-driven sprayers:
- Is it possible to empty the spray tank without having to invert the engine (without turning the sprayer upside down)?
- Is there pressure safety valve present AND does it work properly (prevents pressurisation of the sprayer beyond the maximum working pressure)?
- Are there the power-driven components guarded (pulleys, shafts, gears, flywheels, drive belts and chains) AND are that guards in good condition? (100%)
- Has the fuel cap a retainer, and does fuel tank have a ventilation system present AND does it work properly?
- Are there the covers of hot elements (engine, silencer) present? (100%)
- Are the exhaust outlets located and directed safely for the operator? (100%)
- Are the parts of the engine being under a high voltage insulated to avoid contact with operator? (100%)
- Are there the blower and air guide plates present and are complete AND work properly?
- Is it possible to control the engine AND is the engine speed stable? (100%)

Self-inspection additional questions for electric motor-driven sprayers:
- Are the power-driven components guarded (power transmission to pump and/or blower) AND are they in a good condition? (100%)
- Are the electric elements of the motor properly insulated and fixed? (100%)

Self-inspection additional questions for compression sprayers:
- Is there a pressure safety valve present AND does it work properly? (100%)
- Is it possible to get and keep the pressure in the tank of compression sprayer? (100%)
The protocol of self-inspection of hand-held and knapsack sprayers

The protocol may be printed as the two-page A4 format document (fig. 1 and 2). The introduction part contains owner and diagnostician information as well as sprayer data. Information on sprayer concerns: year of purchase, sprayer type, number and type of nozzles, tank volume. Then there are four main protocol parts for:

- all types of hand-held and knapsack sprayers,
- additional checks for engine-driven sprayers,
- additional checks for electric motor-driven sprayers,
- additional checks for compression sprayers,
- and two supplementary measurement and informative parts:
  - supplementary information on nozzles flowrate by measurement,
  - information on how to use the protocol (range of inspection for different types of sprayers, the importance of questions).

The nozzle output in knapsack sprayers is often unstable (due to decreasing spray pressure) therefore the information on that is treated as a supplementary one. When the calibration of hand-held or knapsack sprayers is going to be done, the tables in the protocol may be used to note the nozzle/s outputs. The measurement of nozzle flow rate and comparison to the nominal one is not recommended. It is recommended to measure nozzle output to check its deviation from the mean value in case of multi-nozzle lances (mean for all nozzles fitted on) or for one nozzle / restrictor fitted on the sprayer (mean for three measurements done in the same conditions). In all cases it is suggested to get the tolerance of deviation being less than 15%.

In the last part there is an information on the scope of the inspection depending on sprayer type inspected. There is also the information present on two types on questions/answers which have to be in 100% positive answered or at least 80% positive answered.

The brochure

The 80-page brochure contains some basic information on knapsack sprayers and their professional use as well as relevant legislation and standards. Furthermore, the construction, mode of operation as well as frequent faults and basic repairs are also included. Some illustrations and drawings help to understand the written information. In the part concerning risks for operator and environment during knapsack and hand-held sprayers use there are some factors listed and information on carried trials is given (presented at SPISE-4). Then two procedures are presented and illuminated or illustrated as well as some suggested measuring equipment is listed. The brochure entitled: “DOBRA PRAKTYKA – Samodzielna kontrola opryskiwaczy ręcznych i plecakowych.” (Best Management Practice – Self-inspection of hand-held and knapsack sprayers) has been published at Ministry of Agriculture and Rural Development and Institute of Horticulture webpages:

http://www.minrol.gov.pl/layout/set/print/Media/Files/2.4_2015-Broszura-DPOR-Samodzielna-kontrola-opryskiwaczy

**Fig. 1** The protocol of self-inspection of hand-held and knapsack sprayers – page 1.
Fig. 2 The protocol of self-inspection of hand-held and knapsack sprayers – page 2.

Conclusions
When some kind of PAE is excluded from the official inspection, there is a need for elaborating the training materials and make it available for trainers and growers, which is the SUD directive demand. The training materials should contain inspection procedure which may be carried out by the grower himself. The procedure have to be simple question checklist, just asking on the presence of the devices on the sprayer and on their condition and functioning. That procedure may be documented in the protocol and in case of the need to obtain equipment certificate (eg. in GAP, IPM certificated production), when the
inspection workshop will not inspect the knapsack sprayer, the grower may get the certificate by carrying on and prove the inspection procedure himself. The illustrated brochure may contain the basis information on the equipment, its faults and risks during use as well as illustrated self-inspection procedure. Such materials may be helpful for the trainers to carry on the trainings as well as for the applicators themselves.

**Literature**

**Acknowledgements**
This work was performed in the frame of Multi-annual Programme “Development of sustainable methods of horticultural production to ensure high biological and nutritional quality of horticultural products and to preserve the biodiversity of the environment and to protect its resources”, financed by Polish Ministry of Agriculture and Rural Development.
Three years experiences of inspection of sprayers - are inspections and repairs carried out equally at all workshops

A. Fjelsted¹

¹ Danish Environmental Protection Agency, Ministry of the Environment, Denmark

By November 2016 all pesticide application equipment in EU needs to be inspected at least once according to the requirement in the EU directive 2009/128/EC. Denmark established a system of inspection nearly three years ago. I would like to give a short presentation of the main successes of the system and give some information about which problems the Danish authorities have experienced so far during the first years of inspection of sprayers. I will discuss the following questions: Was the education of inspectors sufficient? How often do they need updating courses and meetings at which they have a chance to discuss details on how to carry out inspections? Do the inspectors carry out inspection and carry out repairs of sprayers in a uniform way? How to authorities control this? How to make sure that all sprayers are inspected? Which interesting information can be extracted from the database of all sprayers inspected in Denmark - e.g. on which parts of the sprayers are most often being repaired prior to inspection?
Improvements on vertical patternator

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¹ Dipartimento di Scienze Agrarie Forestali e Alimentari – ULF Meccanica, Università degli Studi di Torino

Abstract

The use of a vertical patternator for the adjustment of vertical spray distribution profile of air-assisted sprayers is a useful practice in order to improve the quality of pesticide application. The use of the vertical patternator is currently limited when there is the need to adjust sprayers used to apply pesticides on trees featured by a large canopy volume (e.g. hazelnut) or when tunnel sprayers are used.

In presence of trees with large canopy volume the positioning of the patternator at a half row-distance from the sprayer does not provide optimal results because part of the vegetation to be treated could be out of the spray liquid cloud intercepted by the patternator. To provide solutions to the problem mentioned above experimental tests were carried out with a patternator ad hoc modified by AAMS-Salvarani company. In the modified patternator the line of the collector was inclined of 45° to the sprayer direction from a height of 1.5 m.

The spray profiles obtained with the traditional and with the modified patternators were compared when operating with different sprayer adjustments (liquid flow rate, air speed and direction of the air stream). Comparison was made in terms of spray liquid recovery efficiency and of profiles similitude (patternator diagram and canopy profile).

The results showed a reduction in the patternator efficiency with the modified patternator, but an improvement in the profile similitude.

To allow the use of vertical patternator with vineyard tunnel sprayers AAMS-Salvarani company built a new patternator with opposing elements and a maximum height limited to 2.5 m. The profiles obtained using a vineyard tunnel sprayer and different liquid flow rates and air fan outlet velocities were determined. The results showed the possibility to use the opposing collectors patternator for tunnel sprayer adjustment.

Forword

The use of a vertical patternator for the adjustment of vertical spray distribution profile of air-assisted sprayer is a useful practice in order to improve the quality of pesticide application.

The main purpose of determining the vertical spray distribution profile is the verification of the correct height of distribution to avoid dispersions of the spray mixture above the vegetation (Pergher et al., 2002).

Different models of vertical test benches are available on the market, but all are featured by a similar principle of operation: collection of the liquid - on a vertical plane up to 4 m in height from the ground - sprayed from one side of the sprayer towards the patternator. One of the limit of the models of patternator actually available is their use for the adjustment of sprayers used for applying pesticides on plants expanded in volume. In this type of crop, if the vertical patternator is placed, as usually, at half row distance from sprayer axis, part of the vegetation to be treated could be out of the spray liquid intercepted by the patternator and the obtained vertical distribution profile could not represent the real sprayed diagram (Fig. 1).
Moreover, the patternator actually available on the market are able to intercept the spray liquid only on one side and this limit makes them not suitable for use on tunnel/multi-row sprayers.

In order to try to provide a solution to these present patternators limits, tests has been made using 1) an AAMS-Salvarani company patternator inclined 45° towards the sprayer with the aim to collect all the sprayer output when used for large canopy trees and 2) a new patternators also realized by AAMS-Salvarani company with opposing elements and a maximum height limited to 2.5 m to be used for Tunnel/multirow sprayers.

![Diagram showing vertical patternator limits for spray profile correct height determination](image)

Fig. 1 Example of vertical patternator limits for spray profile correct height determination.

Tests with patternator for large canopy volume tree

Materials and methods

Tests were made using a vertical patternator fitted with discrete stainless-steel spray collectors. The collectors were square plates of 200 x 200 mm size (collecting surface of each single plate equals to 368 cm²), placed on the test bench with a resolution of 200 mm.

To generate different vertical spray profiles a tangential fan (Holder – 150 mm diameter, 1440 mm height) equipped with 3 conventional hollow cone nozzles mounted along the central part of the fan outlet at 300 mm spacing was used. The fan was driven by an electric motor adjusted to obtain an air velocity of 10 ms⁻¹ in correspondence of the collectors positions.
Tests were made using TeeJet TXB8001 and TXB8004 nozzles with a pressure of 1.0 MPa and with the outlet of the fan positioned at 750 mm distance from the collectors. For each setting three test replicates were carried out.

The profiles obtained with a traditional vertical patternator and horizontal air flow were compared to the profiles obtained working with the patternator inclined 45° towards the sprayer and the air flow inclined 45° upwards (Fig. 2). In both cases the air flow was perpendicular to the collectors. The choice of this setting was made to point out the effect of the inclination of the collectors on their performance.

Three criteria for assessing the performance of the patternator according to the different collectors inclination examined were applied (Allochis et al., 2014):

- Spray recovery capacity;
- Reproducibility of the recovery capacity results;
- Spray profile reproducibility.

Spray recovery capacity (RC) was determined measuring the amount of liquid collected by each configuration with respect to the total amount of liquid sprayed during the test, taking in account that the patternator moved in front of the spray cloud during the trials. The recovery capacity 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 patternator in front of the spraying unit
Q is the spraying unit flow rate (ml s\(^{-1}\))

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

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

Finally, to assess the reproducibility of the spray profile, 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 patternator, 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.

\[
SPI = \sum_{i=1}^{n} (\text{max} - \text{min})
\]

Results

The collectors recovery capacity resulted about 30% less for the inclined patternator with respect to the vertical one (-29% for 01 nozzles and -28% for 04 nozzles).

The variability between test replicates (CV) was less than 3% for all examined thesis.

The vertical spray profile obtained with the two positions of the collectors resulted featured by the same shape (Fig. 3, 4). The SPI was 0.09 for 01 nozzles and 0.15 for 04 nozzles.

![Graph showing comparison between inclined and vertical collectors](image)

**Fig. 3** Vertical profile comparison - TXB8001 nozzle – SPI 0.09
The good reproducibility of the results and the low SPI registered indicated that the inclined collectors were able to provide useful information for the proper calibration of the sprayer even if the recovery capacity decreased by 30% with respect to the collectors placed in vertical position. In order to avoid mistakes and to maximize the spray recovery capacity, it is recommended to use the upgrade patternator in vertical position for “normal” canopy and in an inclined position only for large canopy volume tree (Fig. 5).

**Fig. 5** Appropriate use of the upgraded patternator.
Tests with patternator for tunnel / multi row sprayers

Materials and methods

Tests were made using a new version of the AAMS-Salvarani discrete spray collectors patternator characterized by two opposite walls, each consisting of 10 collectors placed in the same position but with the collecting surface rotated of 180°. The same arrangement of the collectors was maintained along the test bench and the maximum height was limited to 2.5 m (10 collectors) in order to pass under the tunnel sprayer (Figure 6).

Fig. 6 The new AAMS-Salvarani double vertical patternator used in the tests

The operating principle of the standard patternator (moving collectors with stationary sprayer) was maintained. However the standard length of the patternator track was increased (900 mm) in order to have a suitable spray liquid recovery. The longer patternator track was necessary because some tunnel sprayers are characterized by spray jets addressed towards the two sides of the row that are not aligned.

A Drift Recovery 600 tunnel sprayer, manufactured by Agricolmeccanica srl, Torviscosa (UD) Italy (ENAMA/ENTAM certificate 05.194-2016) was tested in eight configurations resulting from combining: a) two different air fan setting (air velocity of 4.9 and 8.4 ms-1 measured in correspondence of the collectors), b) two different nozzle types (TeeJet TXB8001 and TXB8004 nozzles) and c) two different tunnel settings: with only one panel activated (single spray) and with both panels activated (double spray).

Tests were carried out using a pressure of 1.0 MPa and with the collectors positioned at 500 mm distance from the nozzles (Fig. 7). For each setting three test replicates were carried out.

For assessing the performance of the patternator according to the different collectors position the same criteria described above for the tests with the patternator for large canopy volume tree were used.
The profiles obtained with the different configurations using the double vertical patternator were compared and analyzed.

Panels of the sprayers

![Diagram of panels and patternator](image)

**Fig. 7** Positioning of the double patternator with respect to the tunnel sprayer.

**Results**

The results obtained using the double spray configuration (side A & B spraying) versus the single one (only side A spraying) showed similar collectors recovery capacity. The recovery capacity differences were linked to nozzle size and air velocity, whereas the patternator structure did not influence this parameter (Tab. 1).

<table>
<thead>
<tr>
<th>Air velocity (ms⁻¹)</th>
<th>4.9</th>
<th>8.4</th>
<th>4.9</th>
<th>8.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single spray</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TXB8001</td>
<td>61.0%</td>
<td>62.2%</td>
<td>61.8%</td>
<td>63.7%</td>
</tr>
<tr>
<td>TXB8004</td>
<td>64.5%</td>
<td>66.1%</td>
<td>65.1%</td>
<td>66.5%</td>
</tr>
</tbody>
</table>

**Tab. 1** Patternator collectors recovery capacity.

The variability among test replicates (CV) resulted less than 3% for single spray profiles and in the range 4-6% for double spray profiles. This increase in variability of results between test replicates may be due to the air turbulence generated in the double spray configuration.
The SPI index calculated by comparing the profile obtained with single spray configuration and the double spray one, both referred to only one side of the tunnel (side A, fig. 7), resulted in a range between 0.08 and 0.12. The SPI index calculated by comparing the profiles of the two sides of the tunnel (side A and side B, fig. 7), obtained with the double spray configuration, resulted are in a range between 0.07 and 0.10 (Tab. 2). All these values represent very similar profiles.

<table>
<thead>
<tr>
<th>Air velocity (ms⁻¹)</th>
<th>Single spray</th>
<th>Double spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9</td>
<td>0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>8.4</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>TXB8001</td>
<td>0.12</td>
<td>0.10</td>
</tr>
<tr>
<td>TXB8004</td>
<td>0.11</td>
<td>0.09</td>
</tr>
</tbody>
</table>

**Tab. 2 SPI index value achieve using the double patternator**

### Conclusion

The use of a vertical patternator fitted with discrete spray collectors in inclined position showed the possibility to better evaluate the sprayer profile in high volume trees. The same discrete spray collectors patternator could be easily used for both “normal” trees and high volume trees adding a tilting device positioned at about 1.5 m height from the ground in order to allow an easy and fast patternator configuration change when needed. The double patternator with two series of collectors placed in opposite position allow to define the spray profile also of tunnel sprayer and could be useful for their adjustment. The influence of the sprayer operating parameters on the patternator performance resulted the same of that obtained using the single side patternator (Allochis et al., 2014). In order to adapt the double side patternator to the different height of tunnel/multi-row sprayers its frame should be realize in a modular way in order to easily adjust the patternator height to the sprayer ones.

### References


### Acknowledgements

Authors wish to acknowledge AAMS-Salvarani company for providing the test benches used in the tests and Agricolmeccanica srl for providing the tunnel sprayer.
Results and Conclusions from Five Years Measuring and Adjusting Air Distribution of Brand New Sprayers for 3D Crops

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Summary

Independent from the physical principle of a fan the vertical angle of the air stream is affecting important parameters of pesticide application in 3D crops (adaptability of the horizontal reach of the air flow to canopy width, spray deposition efficiency, spray drift, fuel consumption, noise emission, work rate, public acceptance, costs). As the vertical angle of the air stream increases, desired effects decrease and undesired effects increase. In order to not only reduce spray drift, but also to increase efficiency of droplet deposition, reduce fuel consumption and further on noise emission and contamination of non-target structures as a cause for severe conflicts with inhabitants of settlement areas nearby orchards and other stakeholder groups, vertical air distribution of fans needs to be improved by sprayer manufacturers to achieve a rectangular distribution pattern with a very low vertical angle of the air stream. This pattern is the key for an adaptation of fan speed to canopy width, allowing the utilisation of canopy adapted spray application with all its benefits. As a technical prerequisite for the improvement of vertical air distribution, fans need to be designed according aerodynamic rules and the variation of the vertical air distribution of individual fans from a series needs to be reduced by increasing accuracy of production of components and during assembly. To enable the grower to use canopy adapted dosing and spray application and to defuse or prevent serious conflicts with stakeholder groups, brand new sprayers also need to be adjusted to the demands of the buyer regarding working height and rectangular air distribution. Therefore adjustment of working height and rectangular vertical air distribution to the needs of the buyer at an air distribution test bench needs to become part of a mandatory testing and adjustment of brand new sprayers before purchase.

Key words: brand new sprayers, canopy adapted spray application, canopy width, cross flow fan, sprayer testing, vertical air distribution.

Introduction

The air support of sprayers for 3D crops is the means of spray droplet transportation into the target structures like fruit trees and grape vines. It is a composite of the air distribution obtained by the construction of the fan and the adjustment of its working height to the maximum target height that is going to be sprayed and the operation as a combination of fan speed (PTO speed and fan gear) and forward speed.

Up to date axial fans without towers are still the most common method of producing the air flow required to transport the spray droplets into the target structure. In its basic version it just uses a mainly circular vertical deflector with a larger diameter as the fan to change the originally axial air stream into a radial one leaving the fan perpendicular to driving direction. Together with radial fans using a fishtail spout they may be classified as point source fans since their radial air distribution has a virtual centre which is positioned relatively close to the orchard floor. Despite the very low position of the fan in relation to the height of target structures, this radial air distribution principally allows the treatment
of tall target structures as tree crops because of an increasing vertical angle of the air stream with 90° as a maximum. However this increasing angle is responsible for many problems created by point source fans.

The most serious disadvantage of the radial air distribution from point source fans is that fan speed cannot be adapted to canopy width, because when adapting it to the bottom of the canopy, the air stream does no more reach the top of the tree and when adapting it to the top of the tree, several rows are sprayed at the bottom of the canopy. As a further consequence of the diverging air stream an increasing travelling distance of the air and the droplets with increasing height of the target requires a higher fan speed compared to fans with cross flow characteristics for treating the same tree height. Operating the same axial fan without and with a tower creating a low vertical angle of the air stream at the same forward speed, the axial fan requires a fan speed approximately 30% higher compared to the tower sprayer. This results in higher fuel consumption and noise emission. As a further consequence of a steep vertical angle of the air stream, fan speed needs to be set to values leading to overshooting at the top of the tree to ensure that it is reached and sufficiently covered with spray droplets. This overshooting causes a significant part of the spray volume delivered into the open atmosphere above the crop, being easily picked up by natural wind and resulting in spray drift at far distances from the orchard. The effect of vertical air distribution on spray drift at 540 min1 PTO high fan gear has been demonstrated by Triloff (2011) which had been reduced by 40% just from exchanging an axial fan by a tower sprayer with all operational settings kept constant.

Another serious disadvantage of a steep vertical angle of the air flow becomes obvious when analysing spray deposit, coverage and droplet deposit density on the leaves over canopy height. Deposition is very unevenly distributed with an excessive deposition at the lower leaf surface increasing as sampling height and canopy width increase. Because of the increasing vertical angle of the air stream even with most tower sprayers as sampling height increases, a manifold of the quantity deposited at the upper leaf surface is deposited at the lower leaf surface. This already becomes visually obvious (Figure 1, Triloff, 2016, unpublished), but is also proven by results from measuring coverage and droplet deposit density through image analysis. It reduces the efficiency of pesticide usage and indicates the relative character of pesticide dose rates. Values of coverage on upper and lower leaf surfaces in three canopy structures with increasing canopy width are shown in figure 2 (Triloff, 2011).

Figure 1: Spray deposits from a fan with cross flow characteristics on the upper (left column) and lower (right column) leaf surface from the top to the bottom of the tree.
These principal effects of the vertical angle of the air stream may be applied to any fan type whatever the physical principle of the fan may be: all the desired effects are decreasing and all the undesired effects are increasing with the increasing vertical angle of the air stream (Figure 3).

The positive features of a low angle of the air stream become even more obvious when the horizontal reach of the air stream is adapted to canopy width, so that almost no more spray mist is blown through the canopy into the neighbouring alley way. This adaptation to canopy width in most cases is obtained by either decreasing fan speed or increasing forward speed or a combination of both. Compared to full fan speed, maximum increase per liter of liquid sprayed of spray deposit (total leaf) reaches up to 35%, while coverage and droplet deposit density at the upper leaf surface are increases by up to 67% and 55% respectively, in super spindle canopy systems.

Parallel to this improvement of spray deposition efficiency when fan speed is adapted to canopy width, spray drift decreases significantly, as do fuel consumption and noise emission. Operating a tower sprayer at 300 min-1 PTO low fan gear and 540 min-1 PTO high fan gear at 6 km h⁻¹ in both cases, results in a potential of reduction of spray drift from small droplet hollow cone nozzles of 90% (Triloff 2011, recalculated).

Fan speed also has an enormous influence on fuel consumption and noise emission which could be demonstrated by evaluations of both parameters from 16 modern fan types with cross flow characteristics used in central European fruit growing regions. Comparing fuel consumption and noise level (dB(A)) measured at 540 min-1 PTO high fan gear with the values obtained at 300 min-1 PTO low fan gear, disclosed a potential of reduction of average fuel consumption of up to 90% and noise level of up to 98%, respectively (Triloff 2016, unpublished).
Table 1: Effect on parameter when the vertical angle of the air stream is

<table>
<thead>
<tr>
<th>Parameter</th>
<th>high</th>
<th>low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptability of the horizontal reach of the air stream to canopy width</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency of spray deposition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of spray cover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canopy adapted pesticide dose rates</td>
<td>negative</td>
<td>positive</td>
</tr>
<tr>
<td>Spray drift</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise emission</td>
<td></td>
<td></td>
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<tr>
<td>Costs</td>
<td></td>
<td></td>
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<tr>
<td>Public acceptance</td>
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**Fig. 3** Effect of the vertical angle of the air stream at the top of fans for 3D crops on parameters important for spray application

These primary advantages of a canopy adapted air support of fans with cross flow characteristics may be exploited for gaining secondary advantages. The increase of droplet deposition efficiency resulting in a 15% increase of spray deposit in broad canopy systems (canopy width 3.2 m) and compensating a 25% reduction in slender spindle systems (canopy width 1.3 m) and a 35% reduction in super spindle trees (canopy width 1.0 m) may be utilized for canopy adapted dosing, reducing pesticide consumption without reducing spray deposit parameters (droplet deposit, coverage and droplet deposit density) and biological efficacy (Triloff 2011). Since decreasing canopy width generally results in smaller row distances requiring less fan speed for canopy adapted spray application despite an increase of forward speed of up to 12 km h⁻¹ and more, enables significant gains in work rate for better usage of climatically suitable time windows for spray application with e.g. low natural wind. The enormous reduction of noise emissions obtained from the adaptation of fan speed to canopy width and a lower duration of the emission by higher forward speeds in slim canopy systems is a first key for a reduction of the risk for severe conflicts with inhabitants of nearby settlement areas. A low angle of the air stream at the top of the fan, the adaptation of fan speed and forward speed to canopy width together with the adaptation of the number of open nozzles to canopy height almost prevents the development of a spray mist cloud above the canopy which is the second key for a reduction of the risk for severe conflicts with local residents. The enormous reduction of fuel consumption obtained from canopy adapted spray application finally also reduces the CO₂ footprint of fruit production and results in a significant reduction of costs for fuel, machinery and labour and adds to financial benefits from canopy adapted pesticide dosing.

The starting point for the utilisation of all these advantages is a fan with a low angle of the air stream and a rectangular air distribution over working height which needs to be adjusted to maximum tree height the sprayer is going to be used for at the individual farm. From measurements of the vertical air distribution with an air test bench “Herbst WP5000” it became obvious, that the air distribution not only of point source fans, but surprisingly of most of the commercially available fan types with cross flow characteristics, is far too
uneven for their safe use especially at low fan speed as it is required in slim canopy structures when using canopy adapted spray application.

Results and discussion

During the past five years more than 230 sprayers with cross flow characteristics have been measured at Marktgemeinschaft Bodenseeobst eG and nearly all of them have been adjusted as brand new sprayers to the working height demanded by the individual growers. Some fans however could not be adjusted at all because of missing or ineffective flaps and deflection plates. These measurements and adjustments disclosed a range of causes for the uneven vertical air distribution of a fan type but also for the remarkable deviations within the individual fans of a series. Interestingly the very most of the causes of the variations are in the range of a few millimetres only, almost never expected to be the cause for the variation of the air distribution measured.

A major reason for the variation of the air distribution of fans is the galvanisation of the housing of the fan and the tower, which may lead to severe deformations of the metal construction requiring manual straightening. Another cause for unpredictable deviations are e.g. circular structures that are not completely circular and therefore do not fit precisely to openings they are welded or screwed to. This may result in sharp edges instead of a radius at sections of the combined structure, reducing the air volume at the corresponding section of the fan. Since size and position of those edges vary accidentally, the resulting disturbance in the vertical air distribution also varies within the individual fans of the series.

In general the use of thermoplastic materials for the construction of fan housings and spouts of radial fans with a flexible tube system is another cause for an unexpectedly uneven air distribution. Very often the cross section of these spouts accidentally varies from concave to convex, slightly modifying the cross section of the opening, causing changes in air flow and distribution, as do rough surfaces of air guiding tubes and spouts made from glass-fiber reinforced polyester resin. An additional cause for variations of air distribution may be the mounting of the spouts under the mechanical tension caused by the bending of the flexible tube, leading to a slight change in shape and orientation when warming up or due to vibrations of the sprayer.

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Short pieces of plastic pipes with a steep angle (e.g. 90°) occasionally used to simplify mounting and preventing a too tight radius of flexible tubes on radial fans may reduce the air flow of an individual tube by more than 25%. Similar losses of air flow by a too tight radius of the tube reducing its cross section have been recorded.

Even the surface structure influences vertical air distribution as could be shown by two sprayers from the same series with the same fan - one with a galvanized fan for integrated production and the second one powder coated for organic production. Although both fans had to be adjusted to the same working height, the powder coated fan demanded very different orientations of the deflection plates compared to the galvanized fan, surpassing the “normal” deviations of the galvanized fans.
In tangential fans very little axial gaps between the rotor and the frame with the bearings may produce a short circuit where the air produced at both ends of the fan is directly sucked back into the fan through these gaps, very likely leading to a shoulder at both ends of the unit of a basically very rectangular vertical air distribution of this fan type.

These examples clearly show that quite a range of causes is responsible for uneven and in some cases unusable vertical air distributions of fans of all kinds of physical principles and constructions, even of fan types which are assumed to provide a perfect air support. All the experiences made in the past years showed that these variations accidentally vary even within the individuals of a series of a fan type and that they are unpredictable. The causes are a widespread disregard of basic aerodynamics in the construction of fans and deviations during production of components and assembly, already starting with the choice of raw materials. That manufacturers of sprayers for 3D crops in the past did not know about these deviations respectively did not pay much or even no attention to the problem until these days, is mainly caused by the demands from the majority of customers. These demands can be observed when no corrective is acting on growers’ opinions: there is a trend to more and more powerful fans, based on the wide spread idea that the more air, the better. As a consequence, poor air distribution of a fan, excessive potential fan power and overdosing air flow in the orchard demand for drift reduction as end of pipe technology: a significant part of the available potential of techniques and methods for drift reduction is consumed by the compensation of avoidable drift because of a fan construction supporting spray drift, excessive potential fan power bought by the grower and overdosing the air flow in the orchard. Besides others, two main reasons for the use of excessive air support are the idea that a high air flow is required for good penetration and spray cover and the experience that most fan types do not allow their safe operation at low fan speed with approximately 300 min-1 PTO low fan gear as a minimum. Therefore the manufacturers in the past did not need to improve air distribution, accuracy of components and during assembly: excessive potential fan power and overdosing air flow in the orchard do not demand for aerodynamic construction and high accuracy of components and assembly, because the poor quality of air distribution in most cases is camouflaged by excessive fan speed.

As can be observed in a number of fruit growing regions, poor air distribution and excessive air flow are not just responsible for negative effects on the efficiency of spray deposition, spray cover, spray drift and fuel consumption, they are also main causes for severe conflicts with local populations because of contamination and noise emission, eventually contributing to further restrictions in the availability and use of pesticides by authorities. The reduction of these very most negative effects of spray application in 3D crops in a first step requires an improved hardware: fans with cross flow characteristics and a low angle of the air stream, constructed according basic aerodynamic rules and with a high quality in terms of materials, production of components and assembly in order to reduce variations in the air distribution of individual fans in a series and to reduce time consumption for air distribution adjustment. Before the purchase of a brand new sprayer, in a second step the air distribution needs to be adjusted individually at an air test bench considering two main parameters: a) the working height which needs to be adjusted to farm specific maximum height of the target structures the sprayer will be used for, and b) the vertical air distribution within that working height, which needs to be adjusted as a rectangle. With a correctly adjusted fan, proven by a protocol, the grower is technically enabled to ap-
ply canopy adapted dosing and spray application. For the correct use of canopy adapted spray application, theoretical and practical training of growers and dealers is required in a third step. Only sprayers with cross flow characteristics and a rectangular air distribution, individually adjusted to farm specific needs, combined with canopy adapted dosing and spray application and components and methods for reducing spray drift will offer a range of benefits to the grower, but also will reduce spray drift even more as just with the use of air induction nozzles without the adaptation of fan speed to the canopy. It is also considered to reduce other negative effects of spray application in 3D crops as it offers the possibility for defusing or preventing serious conflicts with local populations and other stakeholder groups. Therefore within the EU the adjustment of working height and rectangular air distributions need to become part of the very necessary mandatory individual testing and adjustment of brand new sprayers for 3D crops before purchase.

Literature

Survey on problems and criticisms of the inspection service of sprayers in use in Italy

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Abstract

After the issue of the National Action Plan on 14 February 2014, which has introduced the compulsory inspection for all sprayers in use in Italy and has defined the related deadlines and the time intervals between the inspections according to the indications of the European Directive 128/2009/EC, the inspection service, active in all the Italian Regions, grew up both in terms of number of authorized workshops and licensed inspectors.

In spite of the presence of more than 200 workshops and of more than 600 licensed inspectors on the national territory, the activity of inspection of the sprayers in use is still not sufficient to comply with the deadline established by the EU Directive 128/2009/EC, that requires to have all sprayers in use inspected at least once by 26 November 2016 (at present the percentage of sprayers inspected is less than 20%).

With the aim to individuate the reasons and the causes of such unsatisfactory situation an ad hoc survey was carried out, submitting a specific questionnaire to all the Regional officials responsible for the management of the inspection of sprayers in use in Italy.

The questionnaire with multiple answers was divided in three sections dealing with different categories of criticisms:

- Organization problems
- Operative problems
- Economic problems

The questionnaire was submitted to 19 Regions and 2 Autonomous Provinces and 14 answered questionnaires were collected in total, 12 provided by the Regional administrations and two by research institutes that are involved in the inspection of sprayers in use in Italy.

The Regions/autonomous Provinces that participated at the survey were: Piemonte, Campania, Abruzzo, Liguria, Valle d’Aosta, Province of Trento, Veneto, Sicilia, Lazio, Emilia Romagna, Basilicata and Calabria while the research institutes that collaborated to the survey were the CREA-Ing of Monterotondo (Roma) and the University of Milano.

On the basis of the results obtained it was observed that the main reasons which negatively affect the sprayer inspection service in Italy at organizational level, there is the poor information of the farmers/sprayer owners not only about the mandatory inspection and the deadlines foreseen by the EU Directive 128/2009/EC but especially concerning the advantages/benefits that can be achieved through the periodical inspection of plant protection equipment in use.

At operative level, the difficulties encountered mainly concern the status of the sprayers that are carried to the inspections with special regard to the poor external and internal cleaning of the machines, the lack of the safety devices that should be present on the equipment, and the poor fulfilling of the minimum requirements for the sprayer components that are stated by the reference normative (at present still the EN 13790 Standard).
About the economic problems, on the basis of the answers collected in the survey, the costs having a higher incidence for the test stations are represented by the management cost of the site of the test station and by the travel costs that the inspectors have to pay for reaching the farms with the equipment for making the inspections.

**Introduction**

Even if in Italy there is still not an official national register of the sprayers in use, whose realisation is one of the objectives of the National Action Plan (clause. A.3.10), it is estimated that about 600,000 plant protection equipment operate on the national territory, representing the larger sprayer unit number per country in Europe (Wehmann, 2012). These machines are mainly field crop sprayers (31% of total), air-assisted sprayers for bush and tree crops (61%) and sprayers for protected crops (8%).

In Italy first inspections of sprayers in use were carried out in 1980 in the province of Bolzano on air-assisted sprayers for orchards and vineyards, afterwards they were extended also to some other Regions and involved the field crops sprayers too, starting from 1990 (Balsari et al., 2004).

In spite of the fact that sprayer inspections were generally made on a voluntary basis, except for the farms joining the rural development plans in some Regions for which the inspections were mandatory, the inspection service continued to spread up over the years in all the national territory also thanks to the activity made by ENAMA (National Board for Agricultural Mechanisation) and its Technical Working Group for the national coordination of the sprayers inspections (Balsari et al., 2010).

After the issue of the law Dlgs n. 150 / 14 August 2012, that implemented in Italy the EU Directive 2009/128/EC, the sprayers inspection service further increased at national level covering all the Regions and autonomous Provinces and increasing the number of licensed workshops and technicians.

At present 200 authorised workshops are active in Italy (Fig. 1) with 600 inspectors (source: www.centriprovairroratrici.unito.it - Database Nazionale dei centri prova e tecnici abilitati).

![Fig. 1 Evolution of the Authorized workshop in Italy.](image-url)
This increasing number of the workshops, however, did not increase at the same rate the number of inspected sprayers (in 2015 only 12500 sprayers were inspected). Therefore actually the inspected sprayers represent just 17% of the total number of spraying equipment that should be checked before the deadline of 26/11/2016. In order to try to understand the reasons for such an unsatisfactory situation about sprayers inspection in Italy an ad hoc survey was carried out in 19 Italian Regions and in 2 autonomous Provinces.

The survey carried out

The survey was set up taking into account either the technical and operative aspects or the administrative and organizational ones.

In the questionnaire with multiple answers the weight of three categories of problems (organizational, operative and economic) was investigated, assigning a score to each answer provided.

Organizational criticisms

Concerning this type of criticisms the questions submitted concerned the information activity about sprayers inspections made towards the farmers and the sprayers users and the reasons that can limit at organizational level the sprayer inspection activity, including the scheduling of the inspections over the year.

Questions were divided between the reasons influencing directly the execution of the inspections and those hampering their scheduling over time.

The first group of questions with multiple answers dealt with:

- insufficient information of the sprayers owners/users about the mandatory sprayers inspections and the deadlines established by the EU Directive 128/2009/EC;
- limited presence of licensed workshops and technicians on the territory to carry out the sprayers inspections;
- excessive cost of the sprayers inspections;
- limited period of time available over the year to carry out the inspection activity;
- not adequate organisation of the sprayers inspections;
- lack or delay in the implementation of a Regional/Provincial resolution for activating the inspection service.

The second group of questions took into account:

- the lack of a Regional/Provincial coordination of the sprayers inspections;
- the lack of guidelines about the organisation and the scheduling of the inspections;
- the difficulties to reach and to inform the farmers/sprayers users about the inspection activity.

With the aim to assess the importance of the different causes examined, the interviewed persons were asked to assign a priority level to the different answers suggested for each question from 8 (maximum priority) to 1 (minimum priority) for the first group of questions and from 3 to 1 for the second group.
Operative criticisms
In order to analyse the operative aspects related to sprayer inspections, problems that
the licensed technicians may face during the pre-inspection of the sprayer, the functional
inspection and the recording of data registered during the inspection were considered.
In the first question participants were asked to indicate specifically which of these three
phases of the sprayer inspection is more problematic for the technicians.

Economic criticisms
To evaluate this type of problems the items which have more incidence on the costs paid
by the authorised workshops to carry out the sprayer inspection activity were examined.
These items were distinguished between fixed workshops and mobile test stations.
For both the situations the two following items were considered:
- depreciation of the cost paid for the instruments and the equipment used to car-
y out the inspections;
- manpower costs;
For the mobile test stations also the travel costs were considered, while for the fixed work-
shops the management cost of the structure where the inspection activity is carried out
were taken in account.
As for the other criticisms also in this case the participants to the survey were asked to
assign a score in order of priority to each category examined.

Results obtained in the survey
Organizational criticisms

<table>
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<th>A</th>
<th>B</th>
<th>C</th>
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<tbody>
<tr>
<td></td>
<td>Inadequate information</td>
<td>limited number of workshops/inspectors</td>
<td>High inspection costs</td>
</tr>
<tr>
<td>D</td>
<td>Short time for inspection</td>
<td>Inadequate inspection organization</td>
<td>Failure or delay of legislation</td>
</tr>
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</table>

Fig. 2 Main causes of the insufficient inspection activities.

Among the causes that limit the activity of sprayer inspection, the insufficient information
of the farmers/sprayers users resulted the most important one (Fig. 2).
Concerning the second question, dealing with the reasons which hamper the scheduling
of the inspections (Fig. 3), the answer that got the highest score was that related to the
“difficulty in reaching/informing the farmers”, confirming the result obtained in the first
question. Other reasons were: a) the poor collaboration of the farmers Unions in organiz-
ing and scheduling the sprayers inspections; b) the lack of knowledge about the number
of sprayers to be inspected especially due to the lack of a national/regional official reg-
ister; c) the reluctance of the farmers to make their sprayers inspected several months
Fig. 3 Causes that hamper the scheduling of sprayers inspections.

The information level of the farmers/sprayers users about the inspections of sprayers was judged only “sufficient” by 50% of the participants to the survey, while 29% of them considered it “not adequate” and 7% judged it “totally insufficient”.

The subjects involved in the activity of information and dissemination about sprayers inspections resulted mainly the Regional and Provincial administrations (86%), the authorised workshops (64%) and the farmers Unions (64%, Fig. 4).

Fig. 4 Institutions dealing with the information and dissemination about sprayers inspections.

Another question was about the channels used to carry out the information activity about the mandatory inspections of sprayers in use.
Main channels resulted:

- internet (using the regional administrations website as reference), certified e-mails and other media (TV and videos, 71%);
- organization of meetings, conferences, demo days, and participation at fairs and exhibitions (90%);
- realization and distribution of brochures, leaflets, booklets, posters (64%);
- newsletters and papers (articles on farmers bulletins, magazines, 70%);
- dissemination made during the training courses for getting PPP licenses (71%).

Operative criticisms

Main problems were pointed out concerning the pre-inspection of the sprayer, then concerning the functional inspection and finally the record of the inspection data. In details, concerning the pre-inspection phase the problems which occurred with higher frequency were the poor cleaning of the sprayers to be inspected (highest priority) and the not adequate conditions and functioning of the safety devices on some sprayer components (Fig. 5).

Concerning the functional inspection phase more frequent criticisms were the difficulty in inspecting specific components of the sprayer (e.g. due to the poor accessibility to the components mounted on the sprayer and consequently to the difficulties in checking them with the test benches), and the difficulty in checking the electronic devices present on the most recent sprayers (e.g. flowmeters, speed sensors, etc. Fig. 6).

![Fig. 5 Main problems detected during pre-inspection (Photo: G. Oggero, Disafa).](image-url)
Fig. 6 Main problems detected during the inspection.

Concerning the inspection data collection and recording the main problem resulted the difficult to clearly identify the sprayer inspected.

The last question concerning the operative criticisms was the one related to the inspections of brand new sprayers. Participants to the survey were asked to indicate, among five options (0-10%, 30-40%, 50-60%, 70-80%, >80%), the percentage of brand new sprayers (referred to their Region/Province) which failed to pass the inspection.

Only some participants to the survey answered this question, generally indicating the lower percentage range (0-10%, Fig. 7).

Fig. 7 Percentage of brand new sprayers which did not pass the functional inspection.

Economic criticisms

The main cost item for the fixed workshop resulted the management cost of the structure where the inspections are carried out (Fig. 8), while for mobile test stations it resulted the travel costs of technicians and equipment to carry out the inspections (Fig. 9). The other two cost items considered (manpower and equipment) resulted slightly less relevant.
In the final part of the questionnaire participants had the possibility to indicate, choosing among different options proposed, the solutions and actions they considered most appropriate to solve the existing criticisms (Fig. 10).

Concerning the organizational and operative criticisms the main solution indicated was the improvement and the implementation of the information activity towards the farmers, not only about the deadlines for the mandatory inspections of sprayers but also underlining the benefits in terms of functionality of the sprayer that are achievable through the inspections.

Inquiry attendants also indicated that it would be useful to invite the farmers to make their sprayers inspected in pre-determined periods.

Among the solutions proposed to solve the operative problems, priority was given to the need to better inform the farmers on how the sprayer has to be prepared for the inspection.
Finally, concerning the economic problems, that are especially due to the heterogeneity of the fees applied for the inspections in the different Regions (60-150 Euro), the solution proposed deals with the definition of a minimum and of a maximum acceptable cost for the sprayer inspection defined at national level by the Ministry of Agriculture.

![Figure 10: Main solutions evaluated for every type of problem analyzed in the survey](image)

### Conclusions

On the basis of the results obtained in the survey and of the solutions proposed, the information activity towards the farmers and the sprayers users, either in terms of type and level of the information provided or in terms of channels used to disseminate them, has to be considered as a priority to improve the situation of the sprayers inspection service in Italy.

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Acknowledgements

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LIFE-FITOVID Project: Training actions to promote the inspection of sprayers in use in two wine designation of origin of the Basque Country (Spain)

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Summary
In the context of the Life-Fitovid project (LIFE13-ENV-ES-00710) a practical campaign of pre-inspection of sprayers was arranged for raising awareness and training the farmers about the importance of the mandatory inspections of sprayers in use. The target zones correspond to two wine designation of origin located in the Basque Country (Spain): Getariako Txakolina (Designation of Origin in Gipuzkoa province) and Rioja Alavesa (DO Rioja). A total of 136 sprayers were inspected and only 3 successfully passed the inspection. The most common items that does not success the inspection were related to the nozzle flow rate (92%), precision of the manometer (74%) and defaults in PTO protection (67%) but the most important aspects detected were the lack of information of the farmers about the mandatory procedure of the inspections, and the problems detected on sprayers due to defaults in manufacturing or assembling. Training and explanation actions were very welcomed from all participants.

Keywords: viticulture, machinery, calibration, normative, environment.

Introduction
Europe is the world’s leading producer of grape and wine, with almost half of the global vine-growing area and approximately 65% of production by volume (EUROSTAT, 2015). Due to the great economic impact of the viticulture, pesticides has been used to enhance and maintain yields and fruit composition in grapevines (Fermaud et al., 2016). Many factors can harm the vineyards, as downy and powdery mildews. They are important diseases damaging vineyards (Calonnec et al., 2006; Gessler et al., 2010; Jermini et al., 2015). At the same time, this affects the commercial quality of the grapevine and the efficiency of the farm. In this way, to control the fungal pathogens is necessary the use of fungicides.

Many treatments are done by means of air assisted sprayers. These machines favor a better penetration and covering of product on the canopy vegetation (Salcedo et al., 2015) in fruit trees and vineyards. However, a fraction will be lost to the ground or to the atmosphere and it can cause a negative impact on the environment (Pergher and Petris, 2007).

In this context, in September of 2014 started the LIFE project Fitovid about “Implemention of Demostrative & Innovative Strategies to reduce the use of plant protection products (PPP) in viticulture” (LIFE13 ENV/ES/000710). The project is performed in two endemic regions placed in the Basque Country (North of Spain; Figure 1): Getariako Txakolina (Designation of Origin in Gipuzkoa province) and Rioja Alavesa (DO Rioja). These areas differ
in meteorological conditions. They can be considered as representative of other European regions with similar parameters, such as, areas classified under zones C according to Council Regulation (EC) No 479/2008 (i.e. Bordeaux, Portugal, or Bulgaria) or coldest and more humid areas such as the zones A or B (United Kingdom, Alsace, or Czech Republic).

**Fig. 1 Areas inside of Basque Country (Spain) where the project is conducted.**

The project goal is to reduce the negative environmental impact from the production of grape, juice and wine by means of several tasks:

- Evaluating new management strategies to control downy and powdery mildews by decreasing the quantity of applications in endemic Mediterranean and Atlantic areas.
- Checking the effect of “zero residues” fungicides as alternatives to the typical pesticides
- Comparing results obtained in new treatments in different agro-climatic areas.
- Studying chemical residues in grapes, juice and wine in different plant products treatments.
- Improving the pesticides efficiency by demonstrating an imaging device that is able to detect fungal symptoms in its early stages, enabling early treatment.
- Raising awareness to the farmers on the importance of an appropriate maintenance and utilization of air assisted sprayers (or other sprayer equipment) including its influence on the efficiency treatments.
- Using mandatory inspections of sprayers to provide training and information to users.
- Considering the socioeconomical and environmental effect of viticulture.

Taking into account these points, during 2015-16, the Technical University of Catalonia carried out (Figure 2):

- Training sessions to demonstrate the benefits of the inspection process and increasing the general knowledge and awareness in the EU Directive for a Sustainable Use of Pesticides (128/2009/CE).
- Field demonstrations of the benefits of a well efficient application process by good calibrated and adjusted sprayers and beneficial of spray inspections. Farm-
ers are more susceptible to integrate this information when participate personally and adjusted to site-specific conditions than when received through general reports.

- Monitoring the sprayer equipment for quantifying the benefits of an appropriate calibration of the machine.
- Identifications and assessment of the change in attitude.
- Development of diffusion tools on inspection.

![Fig. 2 Practical demonstrations of calibration and inspection in the Basque Country.](image)

In this way, this article is based on the results of a voluntary pre-inspection campaign of about 136 sprayers arranged. In addition, a significant number of farmers were selected for a complete follow up during season during the pesticide application with the sprayer, and the implementation of Best Management Practices (BMP) (Gil et al., 2015).

**Materials and methods**

*Pre-inspection of sprayers*

For the pre-inspection, the procedure was done following the ISO-16122 of inspection of sprayers. According to this procedure, the main parts of the sprayer observed and tested were:

- Legal aspects of the inspection. Verify that the sprayer is on the official register (Registration in the Official Spanish Register of Machinery (ROMA)).
• PTO protection.
• Moving parts protection.
• Level indicator of the tank.
• Leaks.
• Dripping.
• Accuracy of manometers.
• Nozzle flow rate.

**Surveys structure**

Surveys were structured in four parts for a better understanding of the raise awareness from the farmers and their knowledgment in legislation, adjustment and maintenance of the sprayers. The parts were:

• General information. It contained information about the farmer (i.e. age), agricultural conditions (i.e. area, variety), training and agricultural practices.
• Knowledge in European (i.e. European directives) and Spanish legislation (i.e. Action National Plans) and farmer notebook.
• Criteria for the pesticides use. It included determination of the volume rate, BMP and other variables (i.e. treatments number).
• Calibration (i.e. nozzles, pressure, regulation frequency) and regulation sprayers (i.e. drift reduction, cleaning).

**Results**

**Pre-inspection of sprayers**

From a total of 136 sprayers inspected, just a 3 sprayers completely approved the pre-inspection. Figure 3 resumes all the machinery variables supervised and the final results (critical defect or no defect). The main common problems detected were related to the nozzle flow rate (92% presents critical defect), precision of the manometer (74% presents critical defect) and defaults in PTO protection (67% presents critical defect).

![Fig. 3 Resume of the results obtained during the pre-inspection.](image-url)
Comparing with 5 years before (2011) (Figure 4), the 33% of the sprayers passed the PTO protection requirements as currently. Similar happened with the nozzle flow rate (11% in 2011 and 8% in 2016). On the other hand, for the level indicator of the tank, only 21% passed in 2011 instead of the 46% in 2016. Another important improvement was the manometer precision (14% in 2011 instead of 26% in 2016). Finally, for the leaks in the sprayer 82% of sprayers passed in 2011 and 92% in 2016.

![Figure 4](image)

**Fig. 4** Results comparison between pre-inspections in 2011 and 2016.

**Survey results**

The Figure 5 shows the highlight of survey results. Surveys stood out the lack of information of the farmers about the mandatory procedure of the inspections. Only a 20% of the consulted farmers knew the European Directive and the Spanish Royal Decree of Sustainable Use. A 33% said to understand the inspection procedure. A 87% admitted that their sprayers did not pass an inspection. And, at least, the 38% had not registered their sprayers on the Oficial Spanish Register of Machinery.

![Figure 6](image)

**Fig. 6** Graphics about highlights results.
Checking the surveys with more detail, 62% thought that mandatory inspections are an interesting opportunity to learn and improve the condition of the equipment (Table 1). Just a 3% said otherwise. 17% claimed not to know anything about it. In addition, farmers expressed the satisfaction with the trainings and explanation actions.

**Table 1 Opinion about inspections**

<table>
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<th>Questions</th>
<th>(%)</th>
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<tbody>
<tr>
<td>Do not improve the quality of applications of cations</td>
<td>4</td>
</tr>
<tr>
<td>They are an administrative burden</td>
<td>2</td>
</tr>
<tr>
<td>They allow you to have a sprayer in good conditions</td>
<td>16</td>
</tr>
<tr>
<td>They are an interesting opportunity to learn and improve the condition of the equipment</td>
<td>62</td>
</tr>
<tr>
<td>I do not know nothing about inspections</td>
<td>16</td>
</tr>
</tbody>
</table>

**Conclusion**

136 sprayers were inspected in two wine designation of origin located in the Basque Country (Spain) and only 3 successfully passed the inspection. The most common problems detected were related to the nozzle flow rate and precision of the manometer. The most important point observed were the lack of information about the current procedure of the inspections, and the problems on sprayers due to mechanical defaults. All the farmers supported the training and practical demonstrations.

**References**


Control testing of sprayers and air assisted sprayers in Serbia - In anticipation of new legislation

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²Plant Protection Directorate of the Ministry of Agriculture and Environment

In the Republic of Serbia have 138084 tractor sprayers. Over the past 3 years, activities were focused on establishing a system for control testing of sprayer and air assisted sprayers on the territory of the Republic of Serbia. The whole system is based on a 31 station for control testing of machines for pesticides application and 2 bodies who are responsible for control and system organization. In December 2014, the equipment supplied to all stations by its basic activity of agricultural schools, agricultural extension services, professional high schools, agricultural institutes and Universities. The equipment is at each station entrusted to graduate agricultural engineering who have full-time job in the institution which received the equipment. Engineers were trained in two basic courses (2010. and 2011.) and two refreshing course (2014. and 2015.). All stations will be controlled by the two Faculties. These are the Faculty of Agriculture, University of Novi Sad and the Faculty of Agriculture, University of Belgrade. Both of these faculties have the equipment for control testing and additional equipment to verify equipment operation accuracy. Also, these institutions will carry out an annual check of each station. All data, reports will be stored in these two control bodies. The Law for mandatory control testing plant protection machine has passed public discussion and plan is to be on agenda of the parliament in the first quarter of 2017. The plan is to starts mandatory control testing in June 2017. Until then, control testing is non-binding and free.
Session 7

SPISE TWG activities and SPISE advice on PAE not yet considered by harmonised Standards

SPISE TWGS AIMS

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During SPISE 4th Workshop held in Lana (Italy) in 2014, in order to try to further support the mandatory inspections of Plant Protection Equipment (PAE) already in use in the Members States of EU requested by the Directive 2009/128/EC, SPISE Community agreed to establish seven Technical Working Groups (TWGs).

TWGs participation is open to any voluntary person. Each TWG has a Chairman that coordinates the participants. The main aim of these TWGs is to try to provide advice on those items related to the mandatory inspections of PAE that are still not covered by International Standards and for which a harmonization is needed.

The final product of each TWGs work is a SPISE advice that describes a procedure that is not mandatory but can be voluntary adopted in the course of the inspections activities.

Since their establishment (2014) the seven SPISE TWGs have had several meetings and during one of the last meetings it was decided to increase the numbers of the TWGs to cover PAE not yet considered by harmonised Standards. At present the following TWGs are operating:

- TWG 1: Inspection of new sprayers before their delivery (Chairmen: E. Gil, C. Schulze – Stentrop)
- TWG 2: Definition of a common risk assessment procedure for PAE to be exempted from the inspection (Chairmen: B. Huyghebaert, N. Bjugstad, J. Wegener)
- TWG 3: Simplification- additional test methods for inspection (Chairmen: J.P. Douzals, V. Polvêche)
- TWG 4: Quality assurance for workshop activities (Chairmen : J. Kole, P. Harasta)
- TWG 5: Training material (Chairmen: E. Nilsson, H. Kramer, H. Wehmann)
- TWG 6: Sprayer adjustment off field (Chairmen: P. Balsari, J. Langenakens, A. Herbst)
- TWG 7: Train Application – State of the art and parameters to be inspected (Chairmen: J. Kole, P. Balsari, H. Kramer)
- TWG 8: Dusters - State of the art and parameters to be inspected (Chairmen: P. Balsari, E. Gil)
- TWG 9: Microgranulators - State of the art and parameters to be inspected (Chairmen: T. Bals, D. Russell)
- TWG 10: Soil fumigation equipment - State of the art and parameters to be inspected (Chairmen: B. Huyghebaert, J. Declercq, J. Kole)
• TWG 11: Foggers and LVM - State of the art and parameters to be inspected (Chairmen: T. Bals, J. Kole, D. Russell)
• TWG 12: Seed treatment - State of the art and parameters to be inspected (Chairmen: E. Nilsson, J. Kole)

Thanks to the voluntary work of the TWGs two SPISE Advices on sprayers adjustment off-field have been already realized: one related to field crop sprayers and the second to sprayers for bush and tree crops. These two advices as the others that will be produced in future are freely downloadable at the web site: http://spise.jki.bund.de

Some of the activities done by several TWGs have been presented in the previous Sessions while in Session 7 the Chairmen of TWGs 6-7-8-9-10-11-12 will make a short presentation about the activities done and in progress.
SPISE advices on field crop and orchard sprayers’ adjustment at the workshop

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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.
SPISE Advice for functional inspection of special train and other vehicles for chemical weed control on railway and public roads

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The European Directive 128/2009 provides that sprayers used for the weeding of the railways and station areas are subject to a mandatory functional inspection because they have strong impact on the environment, due to the high consumption of herbicides.

A recent Spise survey in Europe showed that the situation in relation to the different types of equipment used is very heterogeneous. Next to special trains designed and built specifically for weed control on the railways (generally equipped with injection system) also exists traditional equipment (boom sprayers, air-blast sprayers, spray lances) adapted to be transported and used on a train or other vehicle able to travel on the railways.

A proper use of special trains designed and built specifically for weed control on the tracks are more challenging than e.g. crop sprayers, because of limited space of nozzle arrangement due to obstacles close to the train like poles (signals, electricity and others) and the need of high forward speed (20-60 km/h) due to high train frequency and limited available time for the treatment. Normally a range of up to 4 m is sprayed from the center of the track to the both sides. However when spraying station areas in some occasions horizontal booms may be used. An optimum positioning of nozzles and use of large drops are needed in order to obtain a proper distribution and low risk of drift combined with the high forward speed used.

Also concerning weed control on public roads, next to special trucks designed and built specifically for weed control on the roads and highways generally equipped with dosing system, can exist traditional equipment (boom sprayers, spray lances or similar, for their functional inspection it shall be adopted EN ISO 16122 Standard parts 1, 2, 3, 4). These special trucks can be considered similar to special trains for weed control.

At present any EN or ISO Standards for functional inspection of special spraying trains and other vehicles for chemical weed control on railways and public roads are available.

With the aim to try to cover this gap of information SPISE TWG7 have realize a document that provides some advice on how to make the functional inspection of special train and other vehicles for chemical weed control on railway and public roads.
Assessment of the applicability of a test protocol for the inspection of dusters in use

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Abstract

It is estimated that more than 200000 dusters, mainly used to apply sulfur dry powder in vineyards to prevent powdery mildew, are in use in Southern Europe. At present there are not reference International Standards for the inspection of in use neither for brand new dusters. In the ambit of SPISE TWG a very first proposal on how to carry out the inspection of dusters in use is under development on the basis of some requirements present in ISO 16122-3 concerning air-assisted sprayers for bush and tree crops and on the basis of some previous experiences made using this type of machinery at DiSAFA – University of Torino.

This first test protocol proposal foresees either to verify some constructive characteristics of the machine or to evaluate its performance, especially in terms of dust flow rate according to the adjustment set.

The applicability of some parts of this test protocol has been checked on three different models of dusters that were tested at DiSAFA – University of Torino. An analysis of the results obtained and of the practical problems faced during the trials is presented.

Introduction

The technique of distributing dry sulfur dust in vineyard is quite widespread, especially in Southern Europe (Italy, Spain, France, Greece, Portugal). In these countries it is estimated that about 200000 dusters are actually in use. Sulfur dust is mainly applied to control grape powdery mildew (Uncinula necatrix), that is a key vine disease. The quality of dust distribution is important in the vineyard protection strategy and even if the total amount of sulfur dust applied yearly in Southern Europe is not known, the high consumption of inorganic sulfur (more than 3000 t/year registered in Italy) and the considerable spreading of organic farms seems to indicate an increasing trend in the use of this product.

Typically, the machines employed for distributing sulfur dust in vineyards are featured by a poor level of technology, and most of them consist in a tank where the sulfur dust is contained, provided with an adjustable opening at the bottom from which the dust falls by gravity on a radial fan which generates an air stream conveying the powder towards the spouts positioned on the two sides of the machine. Precise dosage of the sulfur dust is difficult due to the risks of clogging of the powder in the tank, related both to the sulfur dust physical characteristics and to the conditions of air relative humidity present at the time of the application and to the poor precision of the control system which adjusts the opening of the tank bottom. Also the quality of dust distribution is generally poorly uniform (Marucco and Balsari, 2004), with deposits on leaves and bunches that generally are below 50% of the amount applied.

Other types of dusters, more advanced, are featured by mechanical or by pneumatic systems to extract the powder from the tank and insert it in the air stream generated by the fan; these systems allow a more precise dosing of the sulfur dust and can improve the quality of dust distribution with respect to the conventional models (Marucco and Balsari, 2004).
Sulfur dust is typically very fine as the average size of the particles is generally below 50 \( \mu m \) but precise data are available just for some commercial sulfur dusts and differences in particle size can be due to the different refinement process of the dust (single ventilation, double ventilation, triple ventilation, etc.). Also, environmental humidity has an influence on the smoothness of the sulfur dust and therefore applications made in conditions of high humidity may result in poorer quality of distribution due to the higher risk of sulfur dust clogging in the duster tank. Use of sulfur dust may pose some problems regarding the operator safety, as the material is classified as irritant, and the environment, due to the risk to produce leaf burns if applied on sensitive crops.

Nevertheless, at present there is not an International Standard dealing with the technical features and the performance requirements for brand new dusters. Therefore, according to the recommendations of the EU Directive 128/2009/EC on the sustainable use of pesticides, the functionality of this type of plant protection equipment shall be periodically inspected.

To try to make it possible a first draft of SPISE advice on dusters inspection is under development on the basis of some elements already available in EN ISO 16122-1 and in EN ISO 16122-3 and of some experiences of ENAMA (Italian Board for Agricultural Mechanisation) certification tests (ENAMA test protocol 05f, 2006).

In the draft SPISE advice some pre-requirements taken from EN ISO 16122-1 were taken into account. The following requirements to be checked visually and with the duster in function were considered:

The power take-off (PTO) drive shaft guard and the guard of the power input connection (PIC) shall be fitted and in good condition. In addition:

- the different parts of the shaft, the universal joints and locking systems shall not show excessive wear;
- the PTO drive shaft guard shall be present and shall not show any deformations or tears, and
- in case of non-rotating guards, the restraining device that prevents the rotation of the power take off drive shaft guard shall be present and shall work properly.

Protective devices and any moving or rotating transmission parts shall not be affected in their function.

All guards provided for protection of the operator shall be present and function correctly. Where possible or when not required for the duster function, all access to other moving parts shall be prevented by specific safety devices to prevent any risk to the inspector.

All structural parts and framework shall be in a good condition without permanent deformation, significant corrosion or other defects which could affect the rigidity or the strength of the duster.

This requirement applies also to the hitching device. All guards provided for protection of the operator shall be present and function correctly. Locking of foldable parts of the duster, if present, shall secure these parts in their intended positions.

The blower (fan, casing) shall be in good condition and mounted in a functional manner. Inspection shall verify in particular that:

- all parts are free of mechanical deformation, excessive wear, corrosion sufficient to interfere with safe operation and significant vibration;
• guarding to prevent access to the fan is present.

The blower shall work properly at the nominal working range of PTO speed, e.g. no vibrations due to imbalance, no friction between the body and the fan.

Further requirements to check visually concerning the tank lid, the filling hole and the regulation system were taken, with ad hoc amendments, from EN ISO 16122-3:

The duster tank shall be provided with a lid that shall be well adapted and in good condition. This lid shall be tightly sealed to prevent any dust dispersion and shall avoid unintended opening.

The diameter of the tank filling hole should allow a safe and easy introduction of the dust in the tank.

Devices for adjusting the dust rate (kg/min or kg/h) shall be provided with clear indications (marks) to select the intended rate. These devices shall be lockable in the intended dose rate position and shall be provided with a zero position that enables to switch on the machine without spreading any dust from the spouts.

The SPISE draft test protocol for inspection of dusters in use considered to make a functional test only to assess the performances of the dust dosing system and the uniformity of the air velocity on the two sides of the machine. But up to now any specific methodology has been defined to assess these parameters.

With the aim to make a first evaluation of the applicability of the draft SPISE advice on duster inspection and to try to set up an ad hoc test protocol for functional tests, a preliminary trial was carried out on three duster models.

Materials and methods

The dusters examined

Tests were carried out on three different duster models, all featured by a “gravity” dosing system: 1) a MB G 300 duster (Fig. 1A) equipped with a 50 liters tank, a 300 mm diameter radial fan and a dust dosing system having a range of six different positions from 0 to 5 on the scale of the control system; 2) a Cima 420 S duster (Fig. 1B) equipped with a 200 liters tank, a 400 mm radial fan featured by a nominal air flow rate of 2100 m3/h and a dust dosing system having a range of ten different positions from 0 to 5 on the scale of the dosing control system; 3) a VMA Rodeo LT 300 duster (Fig. 1C) equipped with a 300 liters tank, a 450 mm radial fan featured by a nominal air flow rate of 4300 m3/h and a dust dosing system having a range of eight different positions from 0 to 4 on the scale of the control.

Fig. 1 Duster models tested.
Evaluation of the applicability of the draft SPISE advice

Few technical information were present in the instruction handbook of the dusters, especially concerning the MB G 300 model. On the basis of these few information and making visual checks on the machines, the points of the draft SPISE advice taken from ISO 16122-1 and ISO 16122-3 were applied. No indication about the air velocity generated by the dusters were provided while concerning the dust dose rates, for the MB G 300 model it was just reported that the machine was able to reach a maximum dose rate of 7 kg/min when the control system was set at the maximum position on the scale (n. 5), without any specification about the type of dust employed. For the Cima 420 S it was provided only an indication of the minimum (0.4 kg/min) and maximum (8.0 kg/min) dust dose rate, corresponding respectively to the control system set at the minimum position on the scale (n. 0.5) and at the maximum position on the scale (n. 5), without any specification about the dust type. Finally, for the VMA Rodeo LT 300 a table was reported in the instruction handbook with an indication of the sulfur dust dose rate in function of the setting of the control system (Tab. 1). The values were referred to the application of dry sulfur dust double refined and ultra-ventilated.

<table>
<thead>
<tr>
<th>Position of the control system</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose rate(kg/min)</td>
<td>0.4</td>
<td>1.5</td>
<td>4.0</td>
<td>6.1</td>
<td>7.6</td>
<td>9.6</td>
<td>11.1</td>
<td>12.4</td>
</tr>
</tbody>
</table>

Tab. 1 Nominal sulfur dust dose rate for the VMA Rodeo LT300 duster according to the setting of the control system.

Measurements of air velocity

On all the three duster models air velocity measurements were carried out using a Testo vane probe 16 mm diameter connected to a Testo 400 data logger. Measurements were carried out on the two sides of the machine that was positioned with the center of the spouts at a height of 0.5 m from the ground.

The machines were operated at a PTO speed of 540 rev/min and air velocity was measured in correspondence of the edge of the spouts, positioning the vane probe in at least 6 different positions along the spout profile, and at a distance of 1.5 m from the center of the machine (considering a typical vineyard inter-row distance of 3 m) at three different heights from the ground (referred to typical vineyard canopy heights): 0.5; 1.0 and 1.5 m (Fig. 2).

Fig. 2 Scheme of the air velocity measurements carried out on the duster models tested.
**Measurements of dust flow rate**

A first set of tests were carried out using the MB G 300 duster and the VMA Rodeo LT 300 duster employing kaolin clay dust (Surround® WP manufactured by Novasource®) as test material, in order to avoid the manipulation of sulfur dust which is irritant and can generate environment problems during the test. The kaolin, with an average size of the particles of 3 µm and a density of 0.28 kg/dm³, even if presented physical properties that were not identical to sulfur dust (see Table 2) was considered a possible test material (easy to find, cheap and with low environmental impact) for comparing the dust dose rates related to the different setting of the machines.

<table>
<thead>
<tr>
<th>Material</th>
<th>Average particle size (µm)</th>
<th>Density (kg/dm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaolin clay dust</td>
<td>2–4</td>
<td>0.28</td>
</tr>
<tr>
<td>Sulfur dust triple-ventilated</td>
<td>&lt;44</td>
<td>2.07</td>
</tr>
</tbody>
</table>

**Tab. 2 Main physical characteristics of kaolin dust and of sulfur dust.**

Tests were carried out inserting 3 kg (about 10 liters) of kaolin in the tank, operating the machine in static position at 540 rpm and measuring the time until dust emission from the spouts collapsed (Fig. 3). At the end of the trial the dust residue at the bottom of the tank was measured. For both the machines tests were made setting two different dosages corresponding respectively to the maximum of the scale of the dose control system (n. 5 for the MB duster and n. 4 for the VMA duster) and to an intermediate level (n. 2) and for each thesis three test replicates were carried out.

**Fig. 3 Tests carried out on the MB G 300 duster using kaolin.**

A second set of tests, aimed at evaluating the effects of sulfur type on the performances of the dosing system were carried out using the MB G 300 duster set at the maximum dosage (n. 5 on the scale of the control system) employing two types of sulfur dust: a) Mormino “Zolfo ventilato scorrevole” featured by an average size of the particles < 44 µm and a density of 1.95 kg/dm³ and b) Zanuccoli “Zolfo triventilato 93% S” featured by an average size of the particles < 44 µm and a density of 2.07 kg/dm³. Tests were made filling the tank up to its maximum capacity, weighing it on a weighing platform (PI/WWSE6T, ABC Bilance) featured by a maximum load of 6000 kg and an accuracy of 0.2 kg (Fig. 4), then activating the duster in static position for one minute, weighing again the duster and calculating the dust flow rate by difference of weight. The operation was then repeated ten times until
the dust emission from the spouts collapsed. At the end of the trial the dust residue at the bottom of the tank was measured. For each test three replicates were carried out.

**Fig. 4** Weighing platform used to weigh the duster during the trials.

In order to prevent as much as possible the dispersion of the sulfur dust in the environment the duster was operated in a chamber 2.5 m long realized at the edge of a plastic tunnel 5 m wide and 3.5 m high where two dust preventing nets (Tenax Coveret H) made of polyethylene were placed as tents and a polyethylene sheet was placed on the ground to collect the sulfur dust deposited (Fig. 5).

**Fig. 5** Chamber realized to try to contain the sulfur dust dispersion in the environment during the trials.

**Results**

**Evaluation of the applicability of the draft SPISE advice**

The requirements listed in the draft SPISE advice that were taken from EN ISO 16122-1 and EN ISO 16122-3 and needed only visual inspections resulted applicable and fulfilled for all the three duster models considered.

**Measurements of air velocity**

The MB G 300 duster provided an average air velocity measured at the spout of 37.7 m/s on the right side and of 39.8 m/s on the left side of the machine with a difference of 6% between the two sides of the machine. The highest air velocity values were measured at 0.5 m from the ground and at that height the highest difference between the two sides of the duster (49%) was registered (Tab. 3). The Cima S420 duster presented an average air velocity of 48.1 m/s measured at the right spout edge and an average air velocity of 48.2 m/s measured at the left spout edge with a difference of -0.2% between the two sides of the machine. The values measured at 1.5 m from the machine centre indicated that the
highest values were measured at 1.0 m from the ground and that the average difference between the air velocities registered on the right and on the left side of the machine was only 6%, but with a +117% difference registered at 0.5 m height and a -17% difference registered at 1.5 m height (Tab. 4). Operating the VMA Rodeo 300LT duster an average air velocity of 44.9 m/s was measured at the right spout edge while an average air velocity of 36.1 m/s was measured at the left spout edge with a difference of 24% between the two sides of the machine (Tab. 5). The values measured at 1.5 m from the machine centre indicated that the highest values were measured at 1.0 m from the ground and that the average difference between the air velocities registered on the right and on the left side of the machine was only -2%, but with a +300% difference registered at 0.5 m height and a -43% difference registered at 1.5 m height.

<table>
<thead>
<tr>
<th>Right side A (m/s)</th>
<th>Left side B (m/s)</th>
<th>(A-B)/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average value at the spout</td>
<td>37.3</td>
<td>39.8</td>
</tr>
<tr>
<td>Values measured at 1.5 m from the machine centre</td>
<td>Right side A (m/s)</td>
<td>Left side B (m/s)</td>
</tr>
<tr>
<td>h = 0.5 m</td>
<td>8.8</td>
<td>5.9</td>
</tr>
<tr>
<td>h = 1.0 m</td>
<td>6.5</td>
<td>5.4</td>
</tr>
<tr>
<td>h = 1.5 m</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Average</td>
<td>5.6</td>
<td>4.3</td>
</tr>
</tbody>
</table>

**Tab 3** Air velocities measured using the MB G 300 duster.

<table>
<thead>
<tr>
<th>Right side A (m/s)</th>
<th>Left side B (m/s)</th>
<th>(A-B)/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average value at the spout</td>
<td>48.1</td>
<td>48.2</td>
</tr>
<tr>
<td>Values measured at 1.5 m from the machine centre</td>
<td>Right side A (m/s)</td>
<td>Left side B (m/s)</td>
</tr>
<tr>
<td>h = 0.5 m</td>
<td>2.6</td>
<td>1.2</td>
</tr>
<tr>
<td>h = 1.0 m</td>
<td>9.5</td>
<td>8.5</td>
</tr>
<tr>
<td>h = 1.5 m</td>
<td>6.2</td>
<td>7.5</td>
</tr>
<tr>
<td>Average</td>
<td>6.1</td>
<td>5.7</td>
</tr>
</tbody>
</table>

**Tab. 4** Air velocities measured using the Cima S420 duster.

<table>
<thead>
<tr>
<th>Right side A (m/s)</th>
<th>Left side B (m/s)</th>
<th>(A-B)/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average value at the spout</td>
<td>44.9</td>
<td>36.1</td>
</tr>
<tr>
<td>Values measured at 1.5 m from the machine centre</td>
<td>Right side A (m/s)</td>
<td>Left side B (m/s)</td>
</tr>
<tr>
<td>h = 0.5 m</td>
<td>2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>h = 1.0 m</td>
<td>11.0</td>
<td>10.3</td>
</tr>
<tr>
<td>h = 1.5 m</td>
<td>3.5</td>
<td>6.1</td>
</tr>
<tr>
<td>Average</td>
<td>5.5</td>
<td>5.6</td>
</tr>
</tbody>
</table>

**Tab. 5** Air velocities measured using the VMA Rodeo 300 LT duster.
Measurements of dust flow rate

Using kaolin and the MB G 300 duster and setting the maximum level (n. 5) on the dose control system of the machine an average dust flow rate of 0.39 kg/min was obtained and an average residue of 1.32 kg of powder was collected in the tank at the end of the trial. This value was very low when compared to the nominal one indicated by the manufacturer (7 kg/min) for the same setting of the dose control system. When the dose control system was set in position n. 2 of the scale, a 29% reduction of the dust flow rate was measured (the average value resulted 0.28 kg/min) with an average powder residue in the tank of 1.07 kg.

Employing the VMA Rodeo 300LT duster and setting the maximum level (n. 4) on the dose control system of the machine an average dust flow rate of 0.80 kg/min was obtained and an average residue of 0.34 kg of powder was collected in the tank at the end of the trial. When the dose control system was set in position n. 2 of the scale, a 70% reduction of the dust flow rate was measured (the average value resulted 0.23 kg/min) with an average powder residue in the tank of 0.27 kg. Also in this case the measured values resulted much lower with respect to the nominal ones indicated by the manufacturer (12.4 kg/min and 6.1 kg/min respectively).

Tests made operating the MB G 300 duster with the dose control system set at the maximum level and employing the two types of sulfur dust pointed out that the flow rate changed considerably in function of the tank filling level (Fig. 6). Applying the Mormino sulfur dust the flow rate ranged from 12.1 kg/min when the tank was completely full to only 1.0 kg/min when the dust content in the tank was below 5% of its capacity. The average dust flow rate over 10 minutes of machine functioning resulted 5.9 kg/min and the dust residue in the tank at the end of the trial resulted just 0.8 kg. Using the Zanuccoli sulfur dust the flow rate ranged from 9.9 kg/min when the tank was full to only 1.5 kg/min when the dust content in the tank was below 10% of its capacity. In this case the average dust flow rate over 10 minutes of machine functioning resulted 5.6 kg/min but the dust residue in the tank at the end of the trial resulted much higher (4.3 kg).

![Fig. 6 Trend of sulfur dust flow rate registered with the MB G 300 duster using two different types of sulfur dust and adopting the same dose adjustment (maximum value on the scale of the dose control system = n. 5).](image-url)

The use of the chamber to contain the emission of the sulfur dust in the environment (Fig. 5) enabled to recover about 50% of the sulfur dust applied in the trials.

Comparing the results obtained with the different test materials used in the trials (kaolin, ventilated sulfur Mormino and triple ventilated sulfur Zanuccoli) operating the MB G 300
duster set at the maximum dose rate and with the tank filled at the same level used with the two products (10% of its capacity) considerable differences in terms of dust flow rate and dust residue in the tank were observed (Fig. 7). The use of kaolin produced a flow rate at least 50% lower if compared with sulfur and this seems to limit its use as an alternative material for tests.

**Fig. 7** Dust flow rate and amount of residue in the tank registered in function of the test material used operating the MB G 300 duster set at the maximum dose adjustment (n. 5) and with the tank filled at 10% of its capacity.

**Conclusion**

A SPISE advice for the inspection of dusters in use is difficult to set up due to the lack of a reference Standard for this type of machines. Requirements listed in the actual SPISE draft advice that were taken and adapted from EN ISO 16122-1 and EN ISO 16122-3 and that have to be checked visually resulted applicable on the three duster models examined.

Concerning air velocity measurements, the first results obtained measuring the air velocity at the spout and at a defined distance from the centre of the machine on the two sides of the duster indicated that, according to the duster model, considerable differences can be achieved in terms of symmetry of air distribution. A test protocol for air velocity measurements based on the method adopted in these preliminary trials could be easily defined and added in the draft SPISE advice, eventually providing a threshold level for the symmetry of air distribution on the two sides of the machine.

About dust flow rate measurements, problems were encountered in carrying out the trials also due to the difficulties in managing the dust emitted by the machines. Tests made using kaolin clay dust as test material and filling the tank with a limited amount of powder provided results very different with respect to the nominal values indicated by the manufacturers while tests carried out with sulfur dust indicated that the dose rate depends very much on the tank filling level and is also affected by the specific type of sulfur dust. Further tests are needed in order to verify if, independent of the duster model and of the setting, a consistent relationship can be found between the dust flow rate measured using kaolin and that measured applying sulfur. At present it is therefore difficult to indicate an appropriate test protocol for functional test to assess the dust dose rate applicable in the ambit of the inspections of dusters in use. Efforts are also needed in order to stimulate duster manufacturers to agree on the definition of an International Standard for new machines that should be able to guarantee a constant dose rate in function of the regulation set on the duster. In this sense, the development of innovative technologies for the dust
dosing (e.g. mechanical extraction of the dust from the tank, pneumatic systems, etc.) and for the improvement of the quality of sulfur dust distribution (e.g. enabling a more precise adjustment of the air velocity and using a higher number of adjustable and orientable spouts) should be promoted.

References

TWG 9: Microgranulators

I. Forman¹

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The application machinery involved in the application of micro-granules is many and varied. They can be either stand-alone machines or attached to other machines, such as drills, planters and rolls. With no EU standard available for testing micro granule applicators, the NSTS devised a protocol about 8 years ago. Discussions were held with industry representatives from machine and product manufacturers, farmers and machine specialists and a test standard was produced. With the introduction of Directive 2009/128/EC (Sustainable Use Directive) there is now the requirement to test slug pellet application equipment and this standard was achieved again with full industry involvement. The main objectives are accurate application, environmental and operator safety and food security. Full training is available and a recognised qualification is required for each test procedure before an examiner can start testing machines.
**TWG 10: Soil fumigation equipment**

**J. Kole**

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In the EU directive for a sustainable use of pesticides (2009/128/ec) the periodical inspection of other types of application equipment as sprayers will be mandatory. This means that also other application equipment as sprayers must be inspected. One of the categories of this other equipment are soil fumigation machines.

There are different types of machines. Some are specific dedicated machines, but also built up systems are in use. Different systems of pressuring the liquid are on the market. Because most liquids are very aggressive some types have instead of a pump to pressure the liquid, a liquid tank what is pressured by air pressure created by an external compressor. The liquid is injected in the soil by means of big goose feet what inject the liquid on a depth of 20-40 cm into the soil. Each goosefeet has a working width of 50-75 cm and is equipped with one of more spray nozzles. The soil is loosed by means of a rotary tiller or spading machine and is closed by means of a smooth roll.

Most parts of the machine can be inspected according to the guidelines in EN-ISO 16122:2 but special attention has to be given to the specific elements like the condition and position of the goose feet, the compressor, regulation system, etc.

Because this machines works with very dangerous products, the inspector has to take extra attention to the cleanness of the machine and his own safety.

Based on this protocol special inspection reports are developed based on the general requirements of EN-ISO 16122:1 paragraph 7.
TWG 11: Fogging and LVM equipment

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On base of the EU directive for a sustainable use of pesticides (2009/128/ec) the periodical inspection of other types of application equipment as sprayers will be mandatory before the end of 2016. This includes also the periodical inspection of Low Volume application equipment like thermal (fog) and compression (LVM) misting machines used for example for the application of pesticides in greenhouses and the application of sprout inhibitors in potato storages.

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 in 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.

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 this Technical Workgroup 11 of SPISE has developed this SPISE Advise. This SPISE Advise is based on the experiences in different EU member states like UK, Belgium and the Netherlands and is based on the basic requirements mentioned in Annex II of 2009/128/ec with the use of the systematic and relevant content of the already existing EN-ISO 16122 series.

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.

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 extra requirements.

Because high concentration of pesticides is used with this type of machines, special attention has to pay 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.
TWG 13: Seed treatment - State of the art and parameters to be inspected

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¹ Visavi God Lantamannsed AB, Vellinge Sweden

According to Directive 128/2009/EU equipment for seed treatment should be inspected regularly as they are equipment for application of plant protection products on plants as defined in Regulation 1107/2009/EG. However there is a lack of harmonized standards since CEN has decided not to develop for this kind of equipment. Member states have made different decisions, not to regards this type of equipment or to inspect. Seeds are treated professionally in small quantities on laboratory level, on farms by farmers or contractors coming to farms in larger quantities, tons, up to industrial production in very large quantities, several tons per hour. The equipments in use varies from older, simple mixing devices for smaller batches to modern, sophisticated automatic devices. A special topic is treatment of potato seeds during the planting. As there has been no international standards on this type of machinery, some countries have made national protocols for the performance and safety of the machines. However in most cases the equipment have been built without consideration of standards and thus the performance level varies greatly.

A common practice is that the equipment is used without any quality assurance system neither on machine nor the use on farm level and also some industrial level. On the other hand Germany has already national system for approval of the new machinery and also certifying the seed treatment process. There are examples of laboratories with accreditation of the process including regular calibration of machinery and instrument at short time intervals.

In most cases the equipment is calibrated regarding the applied dose for each batch or at least after change of crops. This can be several time per day.

There is in many situations is clear need for inspection and improvements of the machinery as well as the opposite, where the inspection every three year seems not motivated is there is already a high level of internal control.

Knowing this, it is a challenge to develop general system for inspection of equipment in use as well as regulations for the regular control.

TWG 12 plan to develop a SPISE advice based on national standards and regulations. Input and participation in the work is highly appreciated.
Types of sprayers mostly used and regulation works on sprayer inspection in Turkey

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As is known, Turkey is the European Union member candidate for a long time. In this context, Turkey has transformed many European directives at the different areas into its national directive. Although there is a lot of strutting about the European Union accession, it is quite slow to adopt periodic inspection directives of sprayers in use. Until now, 3 workshops have made in Turkey about periodic inspection tasks of sprayer in use. The first workshop carried out in Adana under organization of Turkish agricultural ministry and results were reported to the government in which attendances declared as sprayer inspection studies should be started. The other two workshops were on arrangements the sprayer inspection procedure and so on. However, later due to difficulties and government policy, Agriculture ministry has issued a notification on spraying agricultural chemicals, sprayers to be used and operator certification requirements. The contents of this notification are so different from EU member inspection procedures. Nowadays this notification is still valid. In this work, sprayer types mostly used, present regulations about sprayers in use in Turkey and also results of a survey studies on the sprayer inspection in Adana province of Turkey are presented.
Sprayer inspection/marketing system in Turkey and agricultural equipment and machinery test centre (TAMTEST)

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In Turkey, there are 1.169 thousand sprayers that consist of approximately 416 thousand field, 117 thousand orchards, 628 thousand backpack sprayer and 18 thousand other types of sprayers in use. Total arable areas are approximately 24 million hectares and about 84 percent of these areas are used for field crop production, others are for orchard plants. Due to this production pattern, field crop boom sprayers are mostly used in Turkey. All the sprayers, dusters, granule applicators etc. are tested by plant protection test unit which belongs to Turkish agricultural equipment and machinery test center before marketing any of the plant protection equipment either they have manufactured in the country or imported in abroad. The sprayer test unit had been charged by a law issued in 1959. New brand sprayers are tested in the sprayer test unit located in Ankara/Turkey considering the requirements for any sprayers and related standards. There is no mechanism to control the sprayers that are in use in our country. In this work, it was given the test procedures and standards we use in sprayer test unit and some statistics about tested equipment and our test benches in Turkey.
An overview of the pesticide application equipment in Ovcepole region in Republic of Macedonia

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¹ University “Goce Delcev” – Stip, Republic of Macedonia

The Directive 2009/128 / EC of the European Parliament establishes a framework for the implementation of National Action Plan referring to the sustainable use of pesticides in every country. One of the areas covered by the Directive relates directly to the introduction of mandatory monitoring and inspection of pesticide application machines. Considering that the Republic of Macedonia does not have a compulsory inspection, and as a country candidate is bound to harmonize its regulations, the basic aim of this research is to determine the current condition of the pesticide application machines. The survey was conducted in the Ovchepole region, which covers the city of Sveti Nikole and surrounding villages. 46 machines were visually and operationally checked. The results of this research will be a good basis for further research and implementation of mandatory inspection of these machines in the Republic Macedonia.
Procedure to control the activity of the inspection workshops in the Region of Aragon (Spain)

A. Jiménez¹, M. Vidal¹, A. Boné¹, F.J. García-Ramos¹

¹Escuela Politécnica Superior. University of Zaragoza. Spain

The Community of Aragon is a Region located in the North-East of Spain. In this area, the Aragon Government is the official body in charge of the mandatory inspection of sprayers in use, so that it must guarantee the correct development of the inspections according to the European Directive 2009/128/CE.

The number of registered sprayers in Aragon is around 16000. Currently, approximately, a 40% of these equipments have been inspected. Inspections are developed by a total of twelve authorized workshops.

The Aragon Government has established a protocol for controlling the quality of work carried out by workshops, based on a control “in situ”, without prior warning, of the workshop activity. To meet this objective, workshops must inform the Administration of their weekly work plan.

The control of the workshop activity is carried out by technicians of the Laboratory of Agricultural Machinery of the University of Zaragoza, which has established a service contract with the Aragon Government.

The main characteristics of the process are: 3-4 controls per year and workshop; revision of devices/instruments used for the inspections; comparative inspection of some sprayers during the “in situ” control. Based on this information, an inspection report is performed.

As example, an “in situ” control includes the following steps:

Identification of members of the workshop.

Identification of responsible of the sprayers.

Check that the inspection activity corresponds to the weekly work plan provided previously by the workshop.

Ask the workshop the inspection report of the last inspected sprayer and of that which is being inspected at that time.

Select a sprayer to carry out a comparative control to check aspects related to: tank, pressures in the system, nozzle flow, ....

The observed discrepancies are described in an inspection report which is sent to the body in charge of the inspections at the Aragon Government.

This procedure, which was implemented two years ago, is allowing a real knowledge of the quality of work done by workshops and also a possibility of advising them to improve the work. As a result of the application of the procedure, a workshop has been sanctioned and its authorization to inspect has been withdrawn.
Assessment of the applicability of a test protocol for the inspection of dusters in use

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¹Dipartimento di Scienze Agrarie Forestali e Alimentari – ULF Meccanica, Università degli Studi di Torino, Italy

It is estimated that more than 200,000 dusters, mainly used to apply sulfur dry powder in vineyards to prevent powdery mildew, are in use in Southern Europe. At present there are not reference International Standards for the inspection of in use neither for brand new dusters. In the ambit of SPISE TWG a very first proposal on how to carry out the inspection of dusters in use is under development on the basis of some requirements present in ISO 16122-3 concerning air-assisted sprayers for bush and tree crops and on the basis of some previous experiences made using this type of machinery at DiSAFA – University of Torino.

This first test protocol proposal foresees either to verify some constructive characteristics of the machine or to evaluate its performance, especially in terms of dust flow rate according to the adjustment set.

The applicability of some parts of this test protocol has been checked on three different models of dusters that were tested at DiSAFA – University of Torino. An analysis of the results obtained and of the practical problems faced during the trials is presented.
Effect of water surface tension on the drops size quality produced by agricultural nozzles

S. Parafiniuk1, A. Subr1,2, M. Milanowski1, A. Krawczuk1

1 University of Life Sciences in Lublin, Poland
2 University of Baghdad, Irak

The aim of the study was to check if the quality of water which was taken from different sources (used for plant protection treatments) influences the change of the droplet size generated by agricultural nozzles. The experiment was done in a laboratory of the University of Life Sciences in Lublin (UP Lublin), and water from 3 different sources was used, demineralized water was used as reference water. There were two treatments of adjuvant (Superam 10AL): with and without adjuvant. The water quality was assessed on the basis of the change of surface tension. The surface tension was measured with a drop Shape Analizer DSA30 device. The Flat Fan, one of the agricultural nozzles widely used by farmers, was used in the study. The measurement was done with spraying pressure of the following values: 2 bar, 3 bar and 4 bar with three repetitions. The droplet size was measured with a laser diffractometer HELOS/R - Sympatec. The results show that using the adjuvant changed the surface tension for all the types of the water sources. However, this change was higher for the water from the farm well (source B) and the tap water from UP Lublin building (source C). This change in the surface tension alters in turn the drops size (Volume Median Diameter) depending on the average results of the spray pattern, but only when using 3-bar pressure.
Online information tool on Sprayer technology for water protection

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¹ TOPPS Project Manager
² University Turin
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⁴ John Deere
⁵ Bertoud
⁶ CEMA

The information tool, which will be available this year in autumn is a joint initiative by sprayer manufacturers (CEMA) and the Crop protection industry (ECPA). It aims to provide relevant information for farmers, advisers and other stakeholders with regard to available sprayer technologies, which can serve as enablers to help prevent losses of pesticides to water, and will be made available in several languages.

Learnings from the TOPPS-projects³ which began in 2005 show that optimized sprayer technology can be a key enabler to reduce the risk of Plant Protection Products (PPP) losses to water.

Method The online information tool for sprayer technology assessment is organized in two modules: a) Field Crop Sprayers and b) Bush & Tree Crop Sprayers.

For each type, visitors of the website are guided through a menu of technology areas relevant for water protection. Key areas are internal & external cleaning, filling, reduction of spray losses, and remnant management. Clicking on the area buttons, opens a list of the respective technologies, which are categorized as follows:

a) required: technologies obligatory for sprayers when following European standards (CEN) and Global standards (ISO) to comply with the European legislation.

b) strongly recommended: these technologies are not currently obligatory, but they are very important to protect water, and may become mandatory in the future.

c) recommended: In this category technologies are indicated which should be considered by farmers when purchasing a new sprayer.

For each technology a short explanation is given including the reasoning with regard to different requirements and recommendations. More detailed information can be accessed by opening an additional information window, showing a picture for clarification, or an outline of the definition from the relevant standard or testing method.

Users of the information tool can indicate by clicking a box if the required technology is available on an existing sprayer, or is intended to be included on a new sprayer (in addition, relevant information with regard to upgrading of sprayers – retrofitting – is included). A summary list of technologies already present on a sprayer with their categorization is available and can be printed.

3. www.TOPPS-life.org
Risk Assessment – Results from European enquiry

M. Stas¹, B. Huyghebaert¹, G. Defays¹, O. Mostade¹, I. Zwertvaegher², D. Dekeyser², J. Declercq², D. Nuyttens²

¹ Walloon Agricultural Research Centre - Agricultural Machines and Facilities Unit – Gembloux, Belgium
² Institute for Agricultural and Fisheries Research – Merelbeke, Belgium

An international enquiry was conducted in the framework of the mandatory inspection of all types of Pesticide Application Equipment (PAE) according to the EU Directive 2009/128. An exemption of inspection of particular types of PAE is only possible following a Risk Assessment for human health and the environment including an assessment of the scale of use of the equipment.

This enquiry was part of a research project conducted in partnership with The Institute for Agricultural and Fisheries Research (ILVO) in Merelbeke. It aimed to establish a state of the art at the EU level, to determine if other Member States are working on the same subject, and to define their approach. The survey was mainly addressed to specialized stakeholders in this issue of inspection of sprayers. It should also help us to apprehend the knowledge of these experts regarding the exemption, the risk analysis, the intensity of use PAE concerned by this issue.

A total of 92 stakeholders were invited to participate in the survey and approximately 21% given response. The results of this survey are relevant but nevertheless incomplete and sometimes inaccurate because the subject is difficult and many “experts” have not mastered the whole issue especially for PAE not yet submitted at a compulsory inspection. The lack of response is also an instructive information; it indicates that the participants (although specialists) do not have a complete knowledge on every PAE or for those subjects (risk assessment and scale of use).
Excursion

The excursion took place on the 14 September 2016. A visit of the Finca Agusti served as possibility for all participants to conduct actively and instructed by a tutor inspections of different types of PAE. Special greenhouse technique was shown and inspected on the occasion of the visit of company of Agromillora.

1 - Meeting point at the Hotel SB BCN Events
2 - Finca Agustí Garcia
3 - Agromillora Iberia
4 - Freixenet wine factory
Programme of the 14th September 2016

8.15  Meeting point at the Hotel SB BCN Events, Ronda de Can Rabadà, 22-24, 08860 Castelldefels

9:00 – 12:00  Finca Agustí Garcia, outdoor, crops: tomatoes and celery.

- Canon mist blower,
- Tank/pump connected to 3 lances (and self-propelled orchard sprayer)
- Boom sprayer

9:45 – 10:15  Break (between station 1 and station 2)

12:00  Departure

13.00 – 14.00  Lunch at Agromillora
14:00 – 17:40  Subirats - Agromillora Iberia, greenhouses

- Presentation of the work lines and facilities of d’Agromillora Iberia

- Brief introduction about Agromillora with special focus on pesticide application in the company

- Tank (400 L)/Pump – Hand-held pulled trolley for greenhouse application

- Presentation of fogger equipment

- Common discussion about PAE for greenhouse inspection

17:40  Departure to Freixenet wine factory

18:00  Visit Freixenet wine factory

19:45  Workshop dinner (Mirador de les Caves – Cal Blay)

22:10  Departure
Results of Session 7: (Please make your own notes)
Closing Session
Results of Closing Session: (Please make your own notes)
Results of Closing Session: (Please make your own notes)
Supporting Documents

CHAPTER III

PESTICIDE APPLICATION EQUIPMENT

Article 8

Inspection of equipment in use

1. Member States shall ensure that pesticide application equipment in professional use shall be subject to inspections at regular intervals. The interval between inspections shall not exceed five years until 2020 and shall not exceed three years thereafter.

2. By 26 November 2016, Member States shall ensure that pesticide application equipment has been inspected at least once. After this date only pesticide application equipment having successfully passed inspection shall be in professional use. New equipment shall be inspected at least once within a period of five years after purchase.

3. By way of derogation from paragraphs 1 and 2 and, following a risk assessment for human health and the environment including an assessment of the scale of the use of the equipment, Member States may:

(a) apply different timetables and inspection intervals to pesticide application equipment not used for spraying pesticides, to handheld pesticide application equipment or knapsack sprayers and to additional pesticide application equipment that represent a very low scale of use, which shall be listed in the National Action Plans provided for in Article 4.

The following additional pesticide application equipment shall never be considered as constituting a very low scale of use:

(i) spraying equipment mounted on trains or aircraft,
(ii) boom sprayers larger than 3 m, including boom sprayers that are mounted on sowing equipment,

(b) exempt from inspection handheld pesticide application equipment or knapsack sprayers. In this case the Member States shall ensure that operators have been informed of the need to change regularly the accessories, of the specific risks linked to that equipment, and that operators are trained for the proper use of that application equipment in accordance with Article 5.
4. The inspections shall verify that pesticide application equipment satisfies the relevant requirements listed in Annex II, in order to achieve a high level of protection for human health and the environment.

Pesticide application equipment complying with harmonised standards developed in accordance with Article 20(1) shall be presumed to comply with the essential health and safety and environmental requirements.

5. Professional users shall conduct regular calibrations and technical checks of the pesticide application equipment in accordance with the appropriate training received as provided for in Article 5.

6. Member States shall designate bodies responsible for implementing the inspection systems and inform the Commission thereof.

Each Member State shall establish certificate systems designed to allow the verification of inspections and recognise the certificates granted in other Member States following the requirements referred to in paragraph 4 and where the time period since the last inspection carried out in another Member State is equal to or shorter than the time period of the inspection interval applicable in its own territory.

Member States shall endeavour to recognise the certificates issued in other Member States provided that the inspection intervals referred to in paragraph 1 are complied with.

7. Measures designed to amend non-essential elements of this Directive relating to amending Annex II in order to take account of scientific and technical progress shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 21(2).

ANNEX II

Health and safety and environmental requirements relating to the inspection of pesticide application equipment

The inspection of pesticide application equipment shall cover all aspects important to achieve a high level of safety and protection of human health and the environment. Full effectiveness of the application operation should be ensured by proper performance of devices and functions of the equipment to guarantee the following objectives are met.

The pesticide application equipment must function reliably and be used properly for its intended purpose ensuring that pesticides can be accurately dosed and distributed. The equipment must be in such a condition as to be filled and emptied safely, easily and completely and prevent leakage of pesticides. It must permit easy and thorough cleaning. It must also ensure safe operations, and be controlled and capable of being immediately
stopped from the operator’s seat. Where necessary, adjustments must be simple, accurate and capable of being reproduced.

Particular attention should be paid to:

1. Power transmission parts
   The power take-off driveshaft guard and the guard of the power input connection shall be fitted and in good condition and the protective devices and any moving or rotating power transmission parts shall not be affected in their function so as to ensure protection of the operator.

2. Pump
   The pump capacity shall be suited to the needs of the equipment and the pump must function properly in order to ensure a stable and reliable application rate. There shall be no leakages from the pump.

3. Agitation
   Agitation devices must ensure a proper recirculation in order to achieve an even concentration of the whole volume of the liquid spray mixture in the tank.

4. Spray liquid tank
   Spray tanks including indicator of tank content, filling devices, strainers and filters, emptying and rinsing systems, and mixing devices shall operate in such a way as to minimise accidental spillage, uneven concentration distribution, operator exposure and residual content.

5. Measuring systems, control and regulation systems
   All devices for measuring, switching on and off and adjusting pressure and/or flow rate shall be properly calibrated and work correctly and there shall be no leakages. Control of pressure and operation of pressure adjustment devices shall be easily possible during application. Pressure adjustment devices shall maintain a constant working pressure at constant revolutions of the pump, in order to ensure that a stable volume application rate is applied.

6. Pipes and hoses
   Pipes and hoses shall be in proper condition to avoid disturbance of liquid flow or accidental spillage in case of failure. There shall be no leakages from pipes or hoses when run with the maximum obtainable pressure for the system.

7. Filtering
   In order to avoid turbulence and heterogeneity in spray patterns, filters shall be in good condition and the mesh size of the filters shall correspond to the size of nozzles fitted on the sprayer. Where applicable the filter blockage indication system shall operate correctly.
8. Spray boom (for equipment spraying pesticides by means of a horizontally positioned boom, located close to the crop or the material to be treated).

The spray boom must be in good condition and stable in all directions. The fixation and adjustment systems and the devices for damping unintended movements and slope compensation must work correctly.

9. Nozzles

Nozzles must work properly to control dripping when spraying stops. To ensure homogeneity of the spray pattern, the flow rate of each individual nozzle shall not deviate significantly from the data of the flow rate tables provided by the manufacturer.

10. Distribution

The transverse and vertical (in case of applications in vertical crops) distribution of the spray mixture in the target area must be even, where relevant.

11. Blower (for equipment distributing pesticides by air assistance)

The blower must be in good condition and must ensure a stable and reliable air stream.
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