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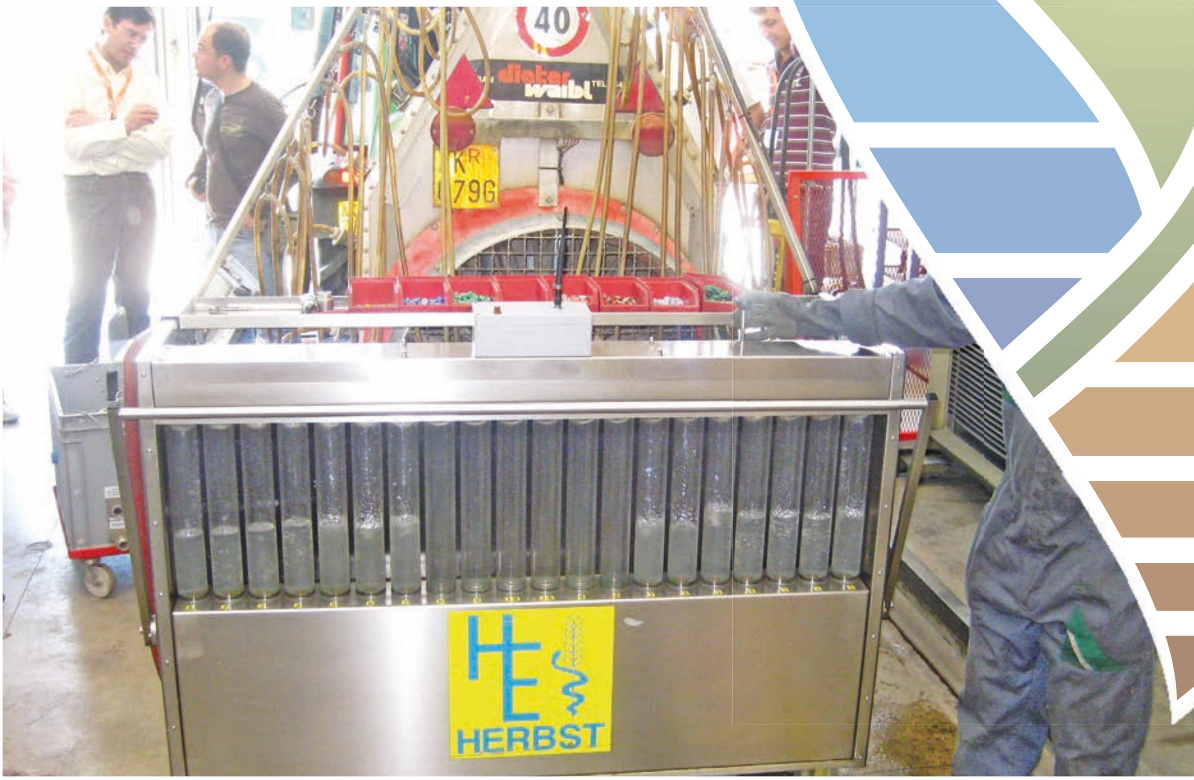
Julius-Kühn-Archiv

Heinz Ganzelmeier, Hans-Joachim Wehmann

Fourth European Workshop on Standardised Procedure for the Inspection of Sprayers in Europe - SPISE 4 -

Lana (South Tyrol), Italy, March 27-29, 2012



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Preface

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

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 workshop, SPISE, took place in April 2004 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 represents 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 can be 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 coordinating 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 Frame Work Directive under the responsibility of the Member States are required.
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.
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.

Group portrait of the SPISE4-participants

Summary

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

The SPISE 4 Workshop took place in Lana, South Tyrol, on 27 to 29.03.2012. More than 100 participants from 29 European countries took part. The Workshop was organised by the SPISE Working Group (SWG), to which representatives from Belgium, France, Italy, the Netherlands and Germany belong (Chairman: Dr.-Ing. H. Ganzelmeier).
The aim of the SPISE 4 Workshop 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.
The Directive determines the key points. The development of procedures between the MS is left to the Member States according to the principle of subsidiarity. They have a fair amount of leeway and are able to take their own experience and conditions into consideration.
The Workshop began with a round table session, where a representative from the Commission (A. Rotteveel) presented the opinion and expectations of DG Sanco. Further speakers reported on the national plan of action (Prof. Freier, DE) and on previous experience with plant protection equipment inspections and their implementation in the Member States (J. van Wenum, NL; Dr. Waldner, IT; H. Wehmann, DE). The involvement of the representative from DG Sanco is also seen as a sign of recognition for the work done by SPISE.
The subject matter for the sessions resulted from the sections of Article 8 of Directive 2009/128/EC:

Session 1:	Inspections at regular intervals – Inspection of new equipment
Session 2:	Member States may apply different timetables and inspection intervals with exceptions following a risk assessment and exempt handheld pesticide application equipment or knapsack sprayers
Session 3:	The inspections shall verify that pesticide application equipment satisfies the relevant requirements
Session 4:	Member States shall establish certificate systems for mutual recognition of the certificates
Session 5:	Training

In addition, two further sessions were included:

After Dinner Speech: Are sprayer calibration, adjustment related to the canopy structure and drift reducing technology added values for orchard/wine growers?

Session 6: Miscellaneous

Contributions from the participants included 10 posters which presented ongoing activities in the Member States and the current situation regarding the introduction of plant protection equipment in the MS.
The After Dinner Speech was geared around becoming acquainted with the technical inspection of air-assisted sprayers developed by the South Tyrolean Extension Service for Fruit- and Wine growing in Lana, which provides for instructions on calibration and adjustment for each individual piece of inspected equipment. The visit to a testing workshop for air assisted sprayers in Auer, where the scope of and the practical procedure for the technical inspection were introduced and then explained, pursued the same aim.
The question is whether it makes sense and would be practical to integrate one or several tools from the Extension Service into the compulsory inspection which takes place at regular intervals according to Article 8 (and must be carried out according to the harmonised EN standards throughout the Member States) as an addition and on the request of growers.
This could result in a win-win situation with considerable advantages for fruit growing, i.e. fruit growers themselves, in addition to the advantages for the consumer, the public and environmental protection.
On the second day an excursion took place to a company called Lochmann in Vilpian (a well-known manufacturer of air assisted sprayers for fruit growing and viticulture), to research centres in San Mi-

chele (presentation of research results on drift reducing technology) and Laimburg (demonstration of air assisted sprayers particularly suited to slopes in viticulture) as well as to a testing workshop of the Extension Service in Auer. In Auer, the technical inspection of an air assisted sprayer was shown using local testing facilities. In an orchard nearby, the spray pattern from the equipment which had been adjusted could be viewed.
The participants were able to gather information on the wide range available from an exhibition of testing facilities by manufacturers from Belgium, Germany and Italy.
Many matters could be discussed and some of them clarified during the Workshop. However, many issues remained unsolved. These are to be brought together in Technical Working Groups and specified further.
The main issues include:

- How to deal with minor defects/brand new sprayers?
- Define a certificate system for mutual recognition
- Define a simplified quality assurances system
- Define a common risk assessment procedure for excluding PAE from the in spections
- Define a procedure for calibration, sprayer adjustment and drift reducing technology as added values
- Collect from MS available training material and make it downloadable on SPISE website
- Develop a SPISE database relevant for monitoring, mutual recognition …

This also shows the effort made by the participants to not only discuss matters, but to also be actively involved in establishing procedures for equipment inspections. In this way technical criteria and procedures within SPISE will be concretised and proposed which contribute to a uniform approach in the MS and concerning mutual recognition.
The survey on the state of equipment inspections in the MS as carried out before each SPISE Workshop and consequently also in the run-up to SPISE 4 shows considerable progress compared to the results from 2009:
The amount of plant protection equipment inspected in 2011 in the EU (all MS) increased from 230,000 to 300,000.
The intervals set by the MS between inspections are 1 to 5 years. Up to now, 16 MS have made use of the exceptional cases according to Article 8.3 of Directive 2009/128/EC and have exempted certain equipment from the inspection or have set different inspection intervals for this. According to notifications from the MS, there are now obviously less items of plant protection equipment. There were less field sprayers in 2011 (1.25 million) compared to 2009 (1.3 million). Air assisted sprayers followed the same trend during this period from 980.000 to 950.000.
The excellent preparation and organisation of the Workshop by the Extension Service in Lana should be noted, and also the constructive and committed attitude to SPISE.
The chairman of the SPISE Working Group, Dr.-Ing. Heinz Ganzelmeier, on whose initiative the SPISE was founded and who was head of the four Workshops, has now passed on this task to Professor Balsari of Turin University (who has also been a member of the organisational team since 2004) since Dr. Ganzelmeier will be retiring at the end of this year.
The proceedings of the SPISE4 workshop will be printed and available as soon as possible.
The presentations will be available on the SPISE website http://spise.jki.bund.de in a short time.
Information portal: **http://spise.jki.bund.de**

Acknowledgement

Special thanks

- to the South Tyrolean Extension Service for Fruit- and Winegrowing, Lana, Italy

for the excellent hospitality and fruitful co-organization,

Furthermore we would like to thank

- the company of Lochmann,
- the Research Centre Edmund Mach Foundation, San Michele all'Adige,
- the Research Centre for Agriculture and Forestry Laimburg

for the very well organized visits.

Opening

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

Dear Dr. Scartezzini – Head of Provincial Department of Fruit- and Winegrowing,
dear Dr. Stauder – Mayor of Lana,
dear M. Santer, President of South Tyrolean Extension Service for Fruit- and Winegrowing, Lana
dear colleagues,
dear ladies and gentlemen,

I would like to open the SPISE 4 Workshop 2012 and welcome you all here to Lana.
I would also like to welcome you on behalf of my colleagues in the SPISE Working Group (SWG).
We are also pleased to be able to welcome so many participants: there are more than 100 participants from 29 countries.
As you can see in the Fig. 1, there are only few countries which haven't sent any representatives.

Fig. 1. Participating states.

The fact that we are able to host the SPISE4 Workshop here in Lana under the management of the South Tyrolean Extension Service for Fruit- and Winegrowing is thanks to you, Dr. Waldner. At our last Workshop in Brno you extended quite a spontaneous invitation to us to come to Lana. We, the SWG, accepted your invitation gladly and without hesitation. This was for several reasons:

1) Lana lies in the midst of an intensive wine and fruit growing region where many different air-assisted sprayers are used.
This gives us the opportunity of getting to know the conditions for viticulture and fruit growing and to have these sprayers as the focus of our consideration for SPISE4.
2) Your Extension Service has developed instructions for calibration and adjustment for its members which are based on test bench measurements (VF, VVP) and which provide fruit growers with crop-specific recommendations for adjusting equipment and dosing PPPs.
We would like to get to know these and think about whether the inspection according to Article 8 (Directive 2009/128/EC) can be added to or extended by your instructions for calibration and crop-specific adjustments.
3) In addition, South Tyrol/Lana is such a beautiful region where many people spend a lot of money for their holidays.
We can gain a lot by being here on the occasion of the SPISE4 Workshop.
We therefore appreciate it very much that
- You, Dr. Scartezzini – Head of Provincial Department of Fruit- and Winegrowing,
- You, Dr. Stauder, as Lord Mayor of Lana,
- You, Mr. Santer, President of South Tyrolean Extension Service for Fruit- and Winegrowing, Lana

have found the time to join us, to welcome us and to present your region and your town to us.

The 1st European Workshop, -SPISE1-, took place in April 2004 prompted by the publication of European Standard 13790.
The 2nd European Workshop, -SPISE 2-, April 2007, provided the MS with information packages, where most of the necessary documents could be found.
The 3rd European Workshop, -SPISE 3-, took place from 22 to 24 September 2009 in Brno (CZ). Here the European Commission's representatives from DG-Environment and DG-Enterprise and the European organisations ECPA, CEMA and COPA attended and made clear their points of view.
Directive 2009/128/EC was published in October 2009. Nevertheless, I believe it is helpful for understanding matters better to address the European Directive properly in order to understand the regulations as a whole and to get to know the expectations which are associated with these by the Commission.
And nobody can do this better than representatives from the European Commission themselves.
I am therefore very pleased to be able to welcome with you a representative from the EC for our SPISE 4 Workshop.
- Mr. Rotteveel, DG SANCO, EC

who will show us Directive 2009/128/EC and explain this to us.
A warm welcome to you.
As we have all learnt, an effective and flexible legislation is not possible in the EU without efficient, competent standardisation.
France holds the secretariat of the CEN/TC 144/WG 3 for developing the relevant harmonised European Standards.
Both project leaders are also with us and I would also like to welcome them.
- Mr. Polveche, responsible for the revision of EN 13790 and
- Mr. Rousseau, responsible for EN 12761, chairman of SC 6 of ISO/TC 23.

The necessary standardisation projects have begun and are in progress.
These will also definitely occupy us intensively in the next few years.

Article 8 of the Framework Directive stipulates the framework which the Member States have decided on together with the Commission and which is to be specified further and implemented by the Member States.

SPISE sees itself as a platform for technically orientated experts for plant protection equipment from the Member States who are interested in a technical procedure which is as uniform as possible and who are prepared to offer their expertise in discussions at Member State level.

The word SPISE symbolises this idea: it means
"Standardized Procedure for Inspection of Sprayers in Europe".

It is not meant for making political decisions, but at the most for making statements or recommendations which could be taken into account for future (political) decisions.
We have set the **Round Table Session** at the beginning of today's workshop so that this technically oriented expert discussion is not one-sided and is not shortened.

The following persons have agreed to take part in this broad and more general discussion:

1) Rotteveel, Anton, DG SANCO, EC
2) Prof. Freier, Julius Kühn-Institut, Braunschweig (Germany)
3) van Wenum, J, Farmer (the Netherlands)
4) Waldner, W., South Tyrolean Extension Service for Fruit- and Winegrowing (Italy)
5) Wehmann, H., Julius Kühn-Institut, Braunschweig (Germany)

I would therefore also like to welcome these colleagues most sincerely.
Our SPISE4 workshop is expected to make a contribution to this.

I think that with the experts present from around 25 Member States, we will be successful at this over the next 3 days.

Once again I welcome you all most sincerely and wish us a successful few days.
Thank you for listening.

Welcoming addresses

Scartezzini, H.
Head of Provincial Department of Fruit- and Winegrowing, Italy

Dear participants in this 4th SPISE-Workshop,
The South Tyrolean Secretary of Agriculture, Hans Berger, sends his warmest regards and hopes you will have a pleasant stay and a successful workshop.

If you look around you here in one of the largest contiguous apple growing areas in Europe, at the vineyards on the hillsides and the densely populated areas on the valley floor, you will easily understand why we attach such great importance to a professional use of pesticide sprayers in the interest of the public welfare.

Even before the three sprayer testing centres were implemented by the Tyrolean fruit industry the provincial authorities had been in favour of sprayer tests and subsequently subsidized the equipment of these testing facilities. The compulsory sprayer tests required by the South Tyrolean IP-programme for pip fruit in 5-year intervals from 1997 onwards were another milestone because they promoted the conversion of all sprayers to drift-reducing spray application.

In 2011 the local government issued guidelines for periodical sprayer tests according to Directive 2009/128/EC.

Since in our region residential areas and intensively cultivated areas are clustered closely together pesticide drift is a highly contentious issue here.

In 2012, after lengthy negotiations, the provincial administration issued a directive regarding the distances to be observed when applying pesticides near residential areas, which takes into account the type of spraying equipment that is used.

The recently issued guidelines for the integrated production of pip fruit, which make the use of cross-flow fan sprayers obligatory in orchards and vineyards bordering on cultivated areas where no pesticides are applied, constitute a further step in the right direction.

The provisions in Article 8 of Directive 2009/128/EC are therefore already operative here without any exceptions for newly acquired sprayers. It is to be feared, however,

that the implementation of Directive 2009/127/EC on a national level regarding this matter will be a lengthy process.

We are of course prepared to adopt the results of this conference for a harmonization of the regulations and expect that they will also find their way into the National Action Plan. As you can see, we are placing high expectations on your work here today, therefore.

I wish you all to make good progress at this workshop.

Santer, M.
Chairman of the South Tyrolean Extension Service for Fruit- and Winegrowing, Andreas-Hofer-Str. 9/1, 39011 Lana, Italy

Dear participants in this 4th SPISE-Workshop,

I am very pleased that you have chosen South Tyrol for this 4th SPISE-Workshop. A month ago I was elected chairman of the South Tyrolean extension service for fruit- and winegrowing with more then 6,000 members. I will try also in future to make sure that our sprayer inspection program keeps pace with the latest technological advances.

I hope that this workshop will provide us all with stimuli to further improve our spray application technique and sprayer testing methods

I wish you a pleasant stay in South Tyrol and a successful workshop

Introduction to the Workshop

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

Some time has passed since the SPISE 3 Workshop in Brno (22. – 24. Sept. 2009) and since then a lot has happened and many things have been clarified.
Directive 2009/128/EC was published on 21 October 2009. Following this, the responsibility for this directive was transferred from the DG Environment to DG Sanco.
It was a while before a first discussion took place between the SPISE Working Group (SWG) and the persons responsible at DG Sanco.
This was on 5 July 2011 with Ms. Pitton, Patrizia (Unit 3 - Plant Protection Products) and Mr. Rotteveel, Anton (Unit - 3 Plant Protection Products).
Fig. 1. shows the colleagues from the SpiseWorkingGroup (SWG), coming from
BE, DE,FR,NL, and IT.

Fig. 1. Members of the SPISE working group.

A result of this discussion with the DG Sanco was

1. to produce a proposal on how inspections can be carried out before harmonised EN standards are available,
2. to carry out inspections on new equipment at the manufacturer's works before it is delivered to the operator since this is a cost-effective and practical approach,

- to put into concrete terms the recognition and monitoring of recognised inspection workshops and to aim at a comparable quality assurance system for all the Member States.

These statements have been incorporated into our agenda for the SPISE 4 Workshop.
As presented in **Fig. 2**, the agenda of the SPISE 4 Workshop shows

1. that the sessions are directly related to the paragraphs of Article 8 but that we have also included further relevant items (evening programs, training, miscellaneous),

2. that the Member States have many further things to specify according to the "Principles of subsidiary.
   On close examination a differentiation can be made between legal regulations und technical specifications.
3. It will be our task to deal with the technical specifications and to put into concrete terms our ideas before other experts from administration can stipulate what the technical specifications should look like and how we should organise the technical procedure.

European Frame and the complementary regulations acc. to the principles of subsidiary

Round table	Art.8 128	Objects and benefits of the obligatory inspection in the EU	Further regulations acc. Principles of subsidiary legal regulations	technical specifications
1	§1&2	MS ensure PAE inspection Regular intervals Deadline New PAE	Conducting inspections Regular inspecting intervals Deadlines Brand new PAE	WS authorization/monitoring/ /rejection Inspection regulation Quality assurance system How to deal with new PAE? How to deal with minor defects?
2	§3	Derogation & exemptions Different timetables & intervals	Exemptions inspection Diff. timetables & intervals Listing in the NAP Training of operators	Risk assessment Assessment of scale of use Training of operators
3	§4	Inspection acc. Annex II	Harmonized standards	How to inspect without EN standards
Even. Progr.	-	Calibration, adjustment, DRT Poster Exhibition	-	Added values by - sprayer calibration - adjustment to the canopy structure - Drift reducing Techniques (DRT)?
-	§5	Regular calibration & checks	Binding user to conduct regular calibration & checks	SWG proposal available Implemented in Eurogap certification
4	§6	Designate Bodies, Certificate systems, Mutual recognition	Designate bodies… Establish certificate systems	Certificate systems consists of sticker and test report SWG proposal available
5	-	Training	Well trained inspectors Statistics reporting	Specification of theoretical+ practical training (content, basics, examination, documents, ppts) Maintenance & repairing
6	-	Miscellaneous	Prohibition of use, offences PAE without valid sticker must not be used	

Fig. 2. European frame and the complemantary regulations acc. to the principles of subsidiary.

Our proposal (the SWG) is to consider in each session whether it would be helpful to set up a Technical Working Group (TWG) so that SPISE does not just talk about issues, but so that concrete ideas are developed.
This TWG which comprises several colleagues from various Member States could then deal with one specific topic and produce a proposal together.
Since the mutual recognition of inspections between the Member States is stipulated by Article 8.6, we will not be able to proceed without a minimum of harmonised "technical specifications".
In my opinion, setting up a TWG is the right solution for such demands.
A further aspect which we have considered in this agenda is the question,
"Is sprayer calibration and adjustment, related to canopy structure and drift reducing technology, an added value for orchard/vine growers?"
This aspect is so significant because the Extension Service here in Lana has developed these tools (sprayer calibration & adjustment related to canopy structure) and implemented these in their voluntary sprayer inspection schema.
We would like to present this inspection schema of the Extension Service to you this evening during the After Dinner Speech and on our excursion tomorrow.
The question which every Member State has to answer for itself is whether it makes sense to integrate one or several tools from the Extension Service into or add it/them to the obligatory inspection according to Article 8) as an addition and on the request of growers.
Due to the positive experience from the previous SPISE Workshop we have organised a day-excursion again which is especially oriented around air-assisted sprayers and their calibration, adjustment and drift reducing techniques.

Our workshop dinner will be on the evening of the second day, to which the head of the research centre in Laimburg, Dr. Oberhuber, has invited us to the institute's stone cellar.
We have planned a roundtable session for the beginning so that our discussion in SPISE4 is centred on a broadly founded basis.

1) Mr. Rotteveel from DG Sanco will be the first to talk to us about the opinions and interpretations / expectations of DG Sanco on Directive 2009/128/EG.
2) Professor Freier, JKI (DE) is our second speaker and will talk about the National Action Plan, taking Germany as an example.
3) Mr. Jaap van Wenum will then speak to us as on farmer from the Netherlands about his opinion on the equipment inspection.
4) Dr. Waldner will be the fourth speaker and will explain the equipment inspection from the Extension Service's point of view.
5) Our fifth speaker, Mr. Wehmann, will present the survey on equipment inspections in the Member States which he has put together using your feedback.

The presentations and discussions will most certainly lead to more clarity and understanding. There will also be many questions which cannot yet be answered satisfactorily.
For this reason it would be important for us to decide whether we want to deal with such topics in SPISE and

1) set up a Technical Working Group to prepare a corresponding proposal or
2) merely collect these topics in the SWG in a to-do list.

In my opinion this would be a decision which would be taken in the respective session.

Round Table

Directive 2009/128/EC on the sustainable use of pesticides

Rotteveel, A.
European Commission, Rue Froissart 101, 1040 Brussels, Belgium

European Commission

Recital 13

Since Directive **2006/42/EC** of the European parliament and of the Council of 17 May 2006 **on machinery** will provide for **rules on the placing on the market** of pesticide application equipment ensuring that environmental requirements are met, it is appropriate, in order to minimise the adverse impacts of pesticides on human health and the environment caused by such equipment, to **provide systems for regular technical inspection of pesticide application equipment already in use**. Member States should describe in their **National Action** plans how they will ensure the implementation of those requirements

3

European Commission

ARTICLE 1: Subject matter

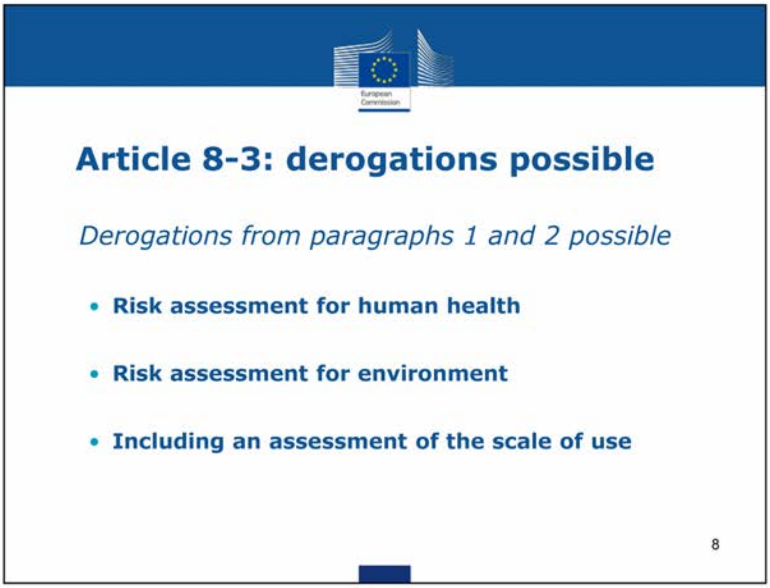
4. 'pesticide application equipment' means any apparatus specifically intended for the application of pesticides, including accessories that are essential for the effective operation of such equipment, such as nozzles, manometers, filters, strainers and cleaning devices for tanks;

4


European Commission
Article 8: Inspection 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
5


European Commission
Afterthought in Article 8-1
New equipment shall be inspected at least once within a period of five years after purchase.
6


ARTICLE 8-2
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.
7


Article 8-3: derogations possible
Derogations from paragraphs 1 and 2 possible
Risk assessment for human health
Risk assessment for environment
Including an assessment of the scale of use
8

European Commission

Member States may (a):

- **Apply different time tables**
- **Different inspection intervals**
- **Pesticide application equipment not used for spraying pesticides**
- **Handheld pesticide application equipment or knapsack sprayers**
- **Additional pesticide application equipment representing a very low scale of use**

To be listed in the national action plans

9

European Commission

No derogation for:

(i) spraying equipment **mounted on trains or aircraft;**

(ii) boom sprayers larger than 3m, including boom sprayers that are mounted on sowing equipment.

10

8-3-b Derogations possible for:

Handheld pesticide application equipment or knapsack sprayers

Member States ensure that operators

- **Are informed on changing accessories**
- **Are informed on risks**
- **Are trained and certified**

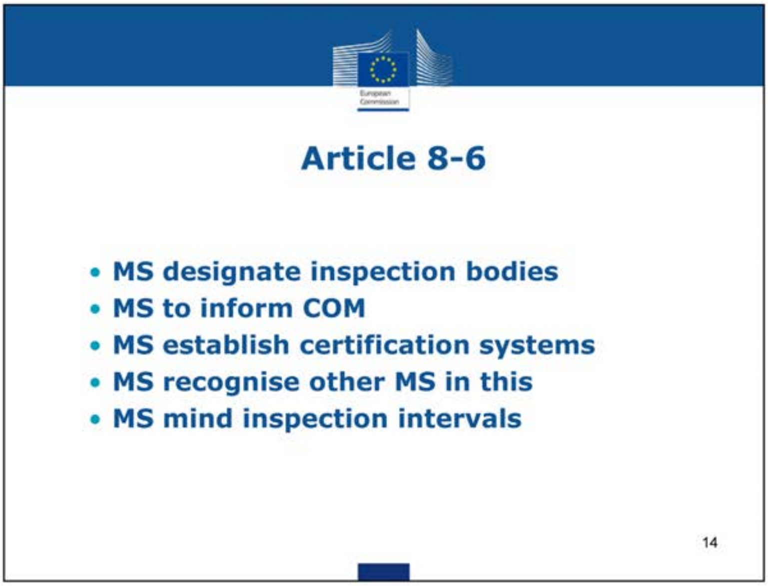
11

Article 8-4 requirements

- **Satisfy Annex II**
- **New equipment developed according to 98/34/EC presumed to comply with SUD (essential health, safety and environmental requirements)**

12

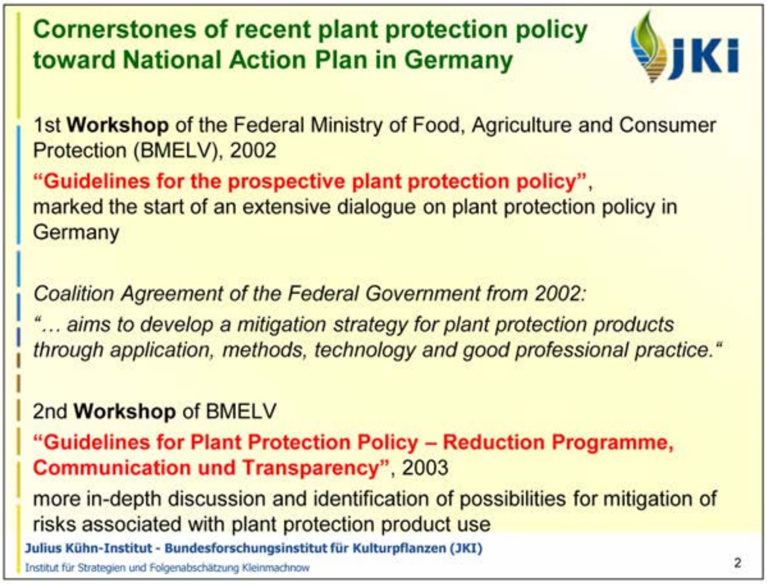

Article 8-5
• Users to check and calibrate own equipment
• Training must prepare for this
13


Article 8-6
• MS designate inspection bodies
• MS to inform COM
• MS establish certification systems
• MS recognise other MS in this
• MS mind inspection intervals
14

National Action Plan on sustainable use of plant protection products in Germany

Freier, B.; Hommel, B.
Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Institute for Strategies and Technology Assessment, 14532 Kleinmachnow, Germany
DOI 10.5073/jka.2012.439.001

Based on discussions on the further plant protection policy the "Reduction Program Chemical Plant Protection" was launched in Germany in 2004. Considering the expected European Directive 2009/128/EC, the Reduction Program was modified to "National Action Plan on Sustainable Use of Plant Protection Products" (NAP) which has been implemented in 2008 and acts as package of new and existing activities mainly aiming on further risk reduction of pesticide use beyond the legal requirements. This plan is directed at all stakeholders who are involved in plant protection. Furthermore, "Principles of Good Plant Protection Practice" were published in 1997, last revised in 2010. This document is addressed to the professional users of pesticides.
The overall aims of NAP are the further risk reduction in plant protection and stronger orientation to Integrated Pest Management (IPM). The main quantitative targets comprise reduction of (a) environmental risk by 25% and (b) exceeding of Maximum Residue Limits (MRLs) in food under 1 % till 2020. Particular emphasis is placed on limiting the use of pesticides to the necessary minimum in order to avoid their unnecessary application and to increase the use of preventive and non-chemical plant protection methods. The set of measures comprises 23 single activities with focus on (a) research and promotion of innovation and (b) improved knowledge and information. Progress is determined with specific indicators, control and monitoring programs, and a network of reference farms. Requirements from environmental stakeholders for indicators like quantitative reduction in pesticide use, permanent buffer zones to water courses or increase of organic farming were not yet included.
After 3 years, the results are promising. Based on the network of reference farms, more than 85 % of all pesticide treatments from 2007 to 2010 complied with the necessary minimum. The 25%-target for risk reduction in the aquatic and terrestrial environment has been achieved for herbicides and insecticides but not yet for fungicides. In 2009 and 2010, the 1%-target for MRLs could be achieved in most but still not in all domestic product groups. The revised NAP is in process and will start 2013. The new plan will consider further indicators and corresponding targets such as environmental indicators or share of organic farming or rate of farms which operate according to crop and sector specific IPM guidelines.


Cornerstones of recent plant protection policy toward National Action Plan in Germany
JKI
1st Workshop of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), 2002
"Guidelines for the prospective plant protection policy",
marked the start of an extensive dialogue on plant protection policy in Germany
Coalition Agreement of the Federal Government from 2002:
"… aims to develop a mitigation strategy for plant protection products through application, methods, technology and good professional practice."
2nd Workshop of BMELV
"Guidelines for Plant Protection Policy – Reduction Programme, Communication und Transparency", 2003
more in-depth discussion and identification of possibilities for mitigation of risks associated with plant protection product use
Julius Kühn-Institut - Bundesforschungsinstitut für Kulturpflanzen (JKI)
Institut für Strategien und Folgenabschätzung Kleinmachnow
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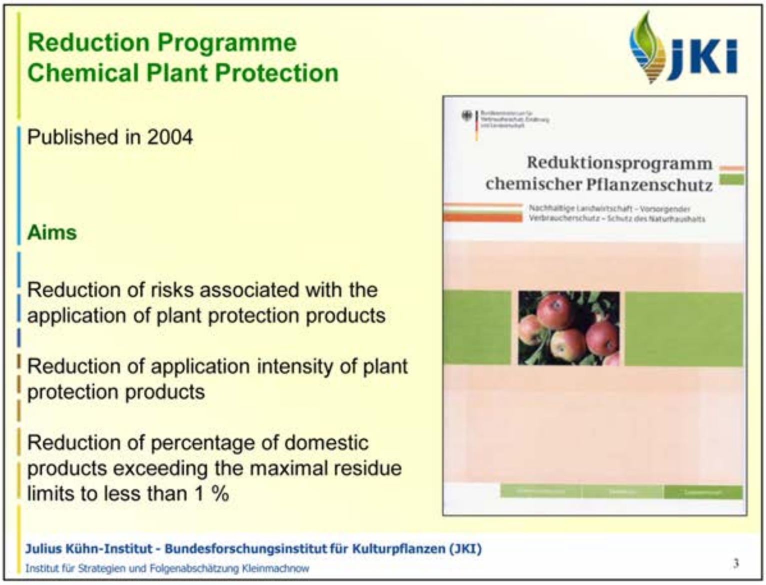
Reduction Programme Chemical Plant Protection
JKI
Published in 2004
Aims
Reduction of risks associated with the application of plant protection products
Reduction of application intensity of plant protection products
Reduction of percentage of domestic products exceeding the maximal residue limits to less than 1 %
Reduktionsprogramm chemischer Pflanzenschutz
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Reduction Programme in Denmark

Pesticide Action Plan I, 1987 - 1996

Bichel –Committee, 1998-1999

Pesticide Action Plan II, 2000 - 2003

Pesticide Action Plan III, 2004 - 2009
Green Growth, 2010 – 2019

- Pesticide tax
- Quantitative reduction aims (Treatment Frequency Index)

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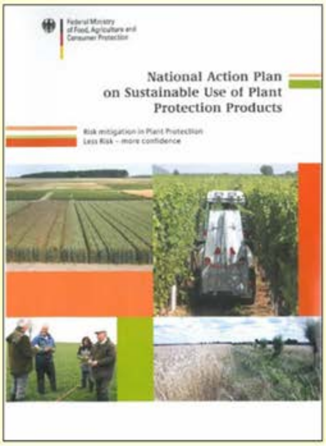
National Action Plan on Sustainable Use of Plant Protection Products

Published in 2008

Further development of Reduction Programme against the background of coming EU-directive



General aims

Further **risk** reduction and

Stronger orientation to **IPM**

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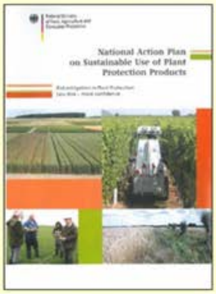
National Action Plan on Sustainable Use of Plant Protection Products

Aims

- Reduction of environmental risk by 25% till 2020 (base line 1996–2005)
- Reduction of exceeding of MRLs in crop products under 1% till 2020
- Limiting the use of pesticides to the necessary minimum
- Increase in use of preventive and non-chemical methods, IPM and organic farming



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Measures

1. Research and Promotion of Innovation Towards IPM

- Innovation Promotion Programme (BMELV)
- Research and development to foster innovation
- Development, testing and transfer of non-chemical plant protection methods
- Advancing computer-aided forecasting methods and decision support systems
- Advancing plant protection **equipment** and introducing **new technologies** into practice
- Promoting resistance research and breeding of resistant varieties
- Demonstration of new integrated plant protection methods (e. g. demonstration farms)
- Development and use of crop and sector-specific guidelines on IPM
- Hot spot management
- Promotional programmes to foster IPM methods and organic farming

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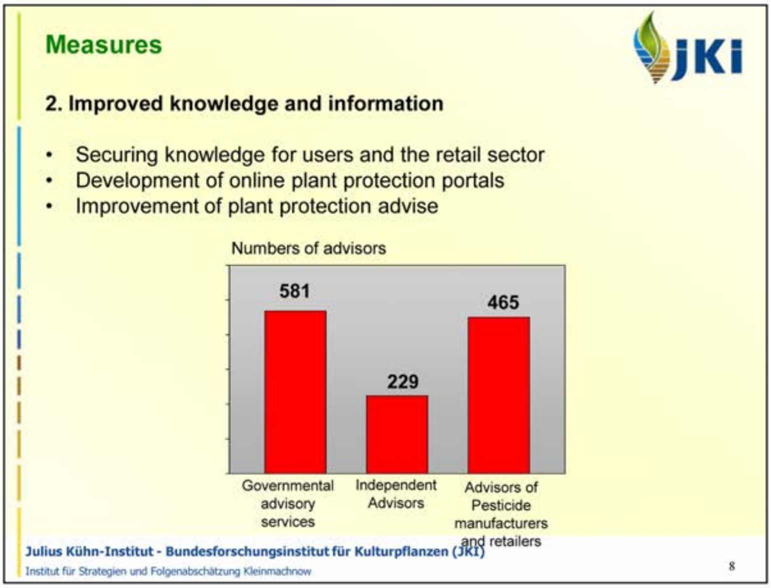
Measures
2. Improved knowledge and information
• Securing knowledge for users and the retail sector
• Development of online plant protection portals
• Improvement of plant protection advise
Numbers of advisors
581
229
465
Governmental advisory services
Independent Advisors
Advisors of Pesticide manufacturers and retailers
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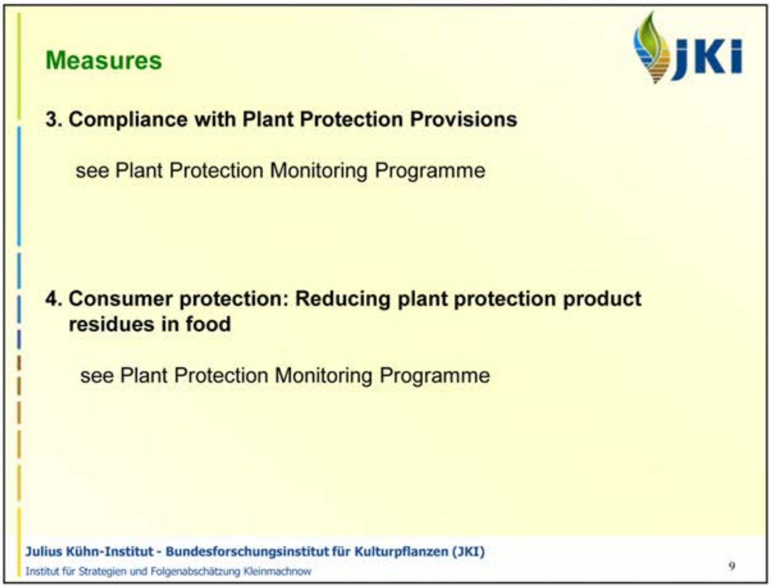
Measures
3. Compliance with Plant Protection Provisions
see Plant Protection Monitoring Programme
4. Consumer protection: Reducing plant protection product residues in food
see Plant Protection Monitoring Programme
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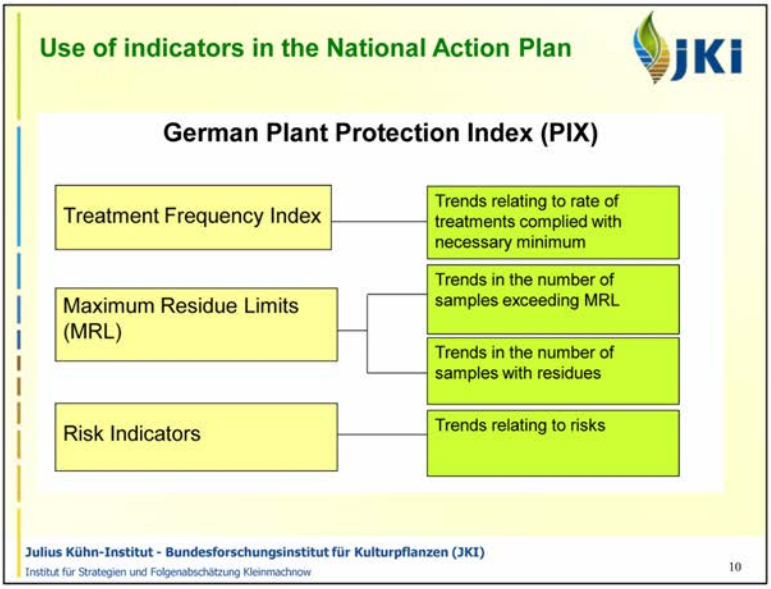
Use of indicators in the National Action Plan
JKI
German Plant Protection Index (PIX)
Treatment Frequency Index
Trends relating to rate of treatments complied with necessary minimum
Maximum Residue Limits (MRL)
Trends in the number of samples exceeding MRL
Trends in the number of samples with residues
Risk Indicators
Trends relating to risks
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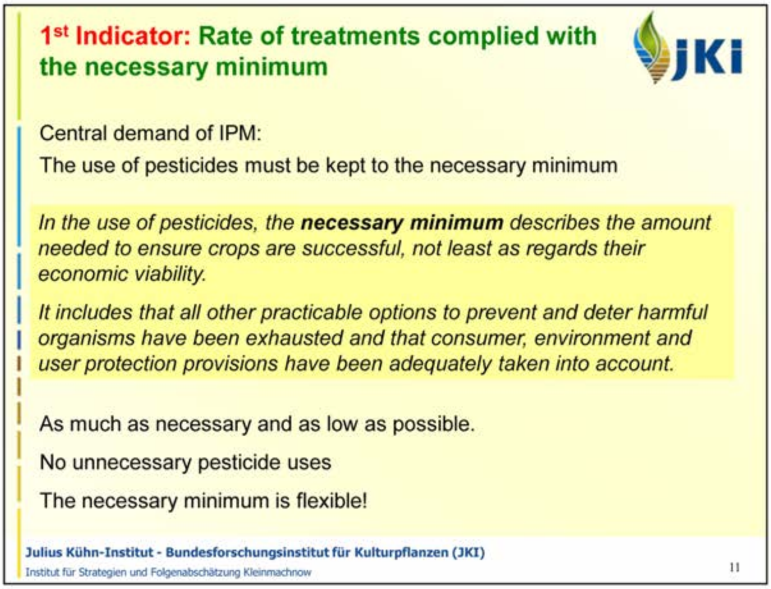
1st Indicator: Rate of treatments complied with the necessary minimum
JKI
Central demand of IPM:
The use of pesticides must be kept to the necessary minimum
In the use of pesticides, the necessary minimum describes the amount needed to ensure crops are successful, not least as regards their economic viability.
It includes that all other practicable options to prevent and deter harmful organisms have been exhausted and that consumer, environment and user protection provisions have been adequately taken into account.
As much as necessary and as low as possible.
No unnecessary pesticide uses
The necessary minimum is flexible!
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Treatment frequency index

Indicator for intensity of pesticide use

First established in Denmark (Kudsk, 1989)

*The **treatment frequency index** lists the number of times a pesticide is used on an area, taking account of any dosage reductions and whether only partial areas are treated. Pesticides applied in mixed tanks are listed separately.*

Use of a pesticide in the maximum allowed dosage: **1.0**
Use of a pesticide in half dosage: **0.5**
Use of a pesticide on 50 % of area: **0.5**

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Network of Reference Farms for Plant Protection

Joint project of

- Ministry for Food, Agriculture and Consumer Protection,
- State Plant Protection Services and
- Julius Kühn-Institut, Federal Research Centre for Cultivated Plants

Aims

1. Generation of annual data on **pesticide use intensity** (treatment frequency index) in main crops of farms
2. Expert **evaluation** of treatment intensity in terms of the **necessary minimum** of pesticide use (general principle of IPM)

Approx. 120 experts from German State Plant Protection Services are involved

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Network of Reference Farms for Plant Protection

In 2010:

Crop	Number of Farms	Number of Fields
Winter wheat	86	246
Winter barley		198
Winter oil seed rape		168
Other arable crops		165
Cabbage	28	68
Carrots		
Asparagus		
Onions		
Apples	19	56
Viticulture	9	24
Hops	3	14

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Distribution of Reference Farms for Arable Crops in Regions of Germany in 2010

19 arable cropping regions

Four main regions:

- North
- East
- South
- West

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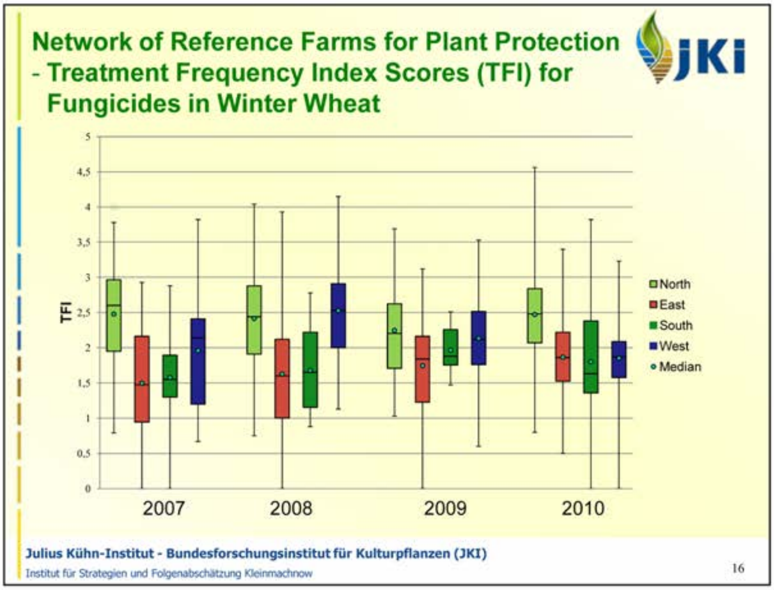
Network of Reference Farms for Plant Protection
- Treatment Frequency Index Scores (TFI) for
Fungicides in Winter Wheat
JKI
TFI
North
East
South
West
Median
2007
2008
2009
2010
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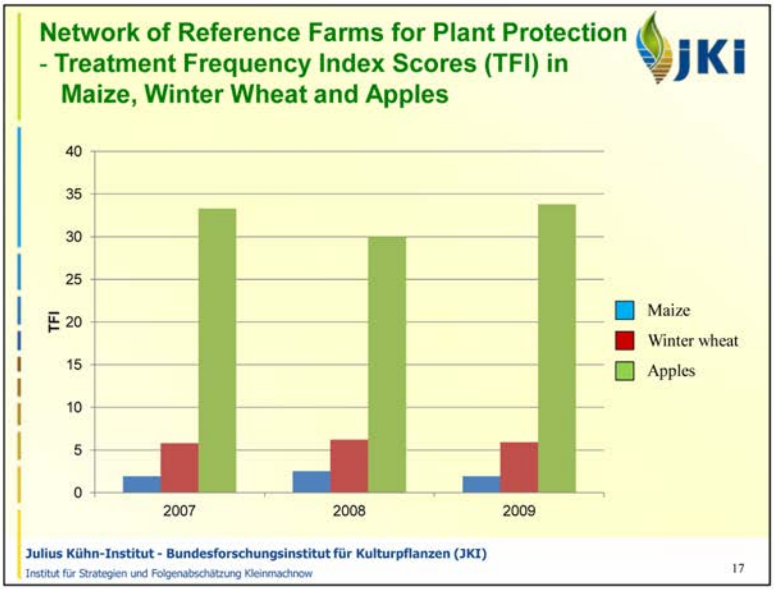
Network of Reference Farms for Plant Protection
- Treatment Frequency Index Scores (TFI) in
Maize, Winter Wheat and Apples
JKI
TFI
Maize
Winter wheat
Apples
2007
2008
2009
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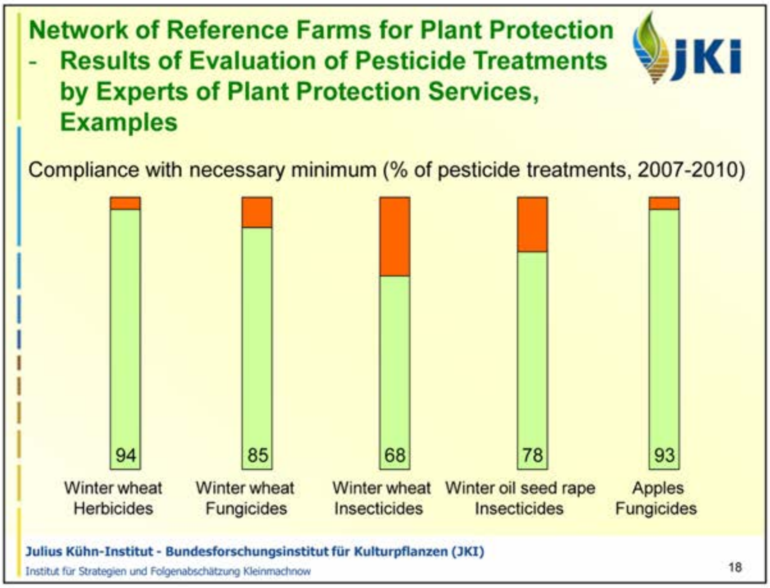
Network of Reference Farms for Plant Protection
- Results of Evaluation of Pesticide Treatments by Experts of Plant Protection Services, Examples
JKI
Compliance with necessary minimum (% of pesticide treatments, 2007-2010)
94
85
68
78
93
Winter wheat Herbicides
Winter wheat Fungicides
Winter wheat Insecticides
Winter oil seed rape Insecticides
Apples Fungicides
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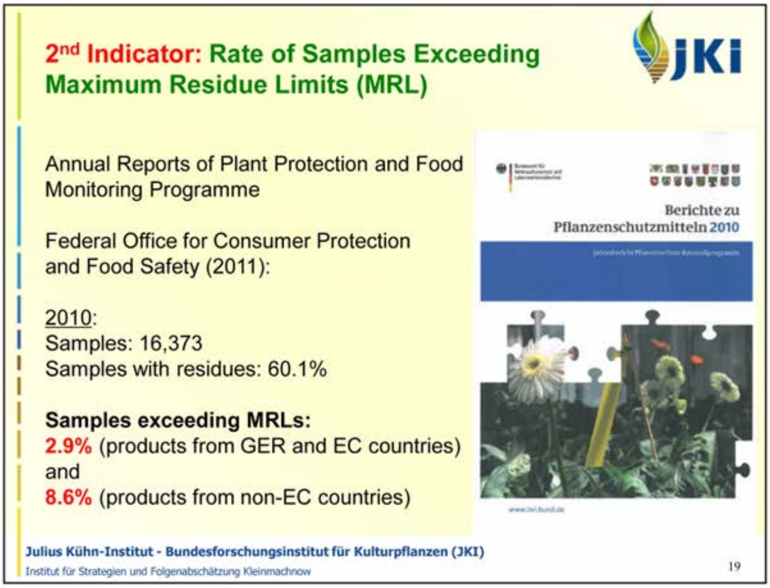
2nd Indicator: Rate of Samples Exceeding Maximum Residue Limits (MRL)
JKI
Annual Reports of Plant Protection and Food Monitoring Programme
Federal Office for Consumer Protection and Food Safety (2011):
2010:
Samples: 16,373
Samples with residues: 60.1%
Samples exceeding MRLs:
2.9% (products from GER and EC countries)
and
8.6% (products from non-EC countries)
Berichte zu Pflanzenschutzmitteln 2010
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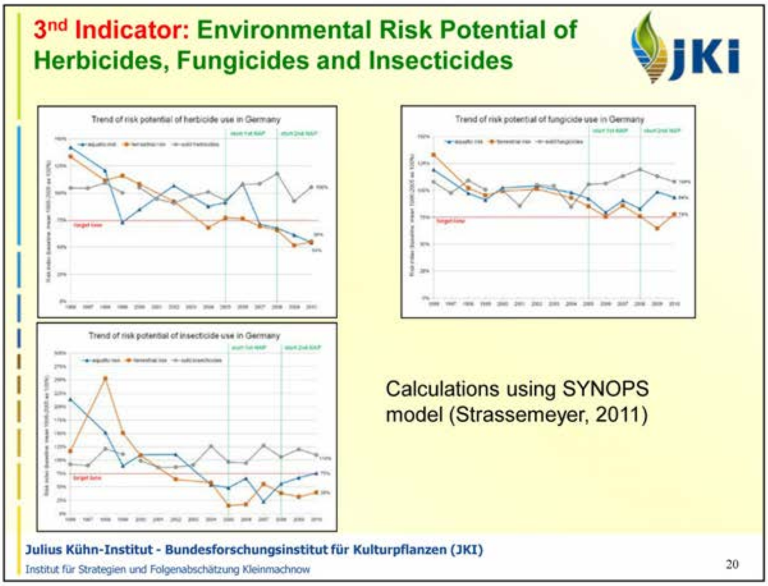
3rd Indicator: Environmental Risk Potential of Herbicides, Fungicides and Insecticides
JKI
Trend of risk potential of herbicide use in Germany
Trend of risk potential of fungicide use in Germany
Trend of risk potential of insecticide use in Germany
Calculations using SYNOPS model (Strassemeyer, 2011)
Julius Kühn-Institut - Bundesforschungsinstitut für Kulturpflanzen (JKI)
Institut für Strategien und Folgenabschätzung Kleinmachnow
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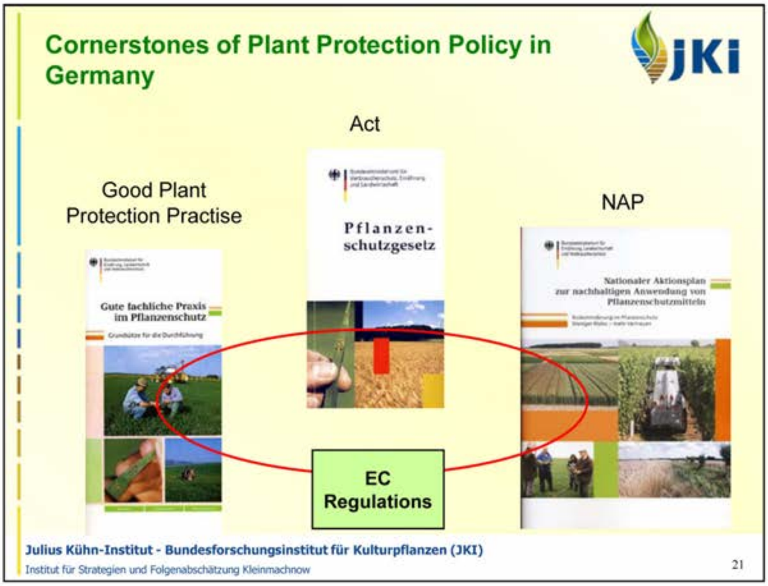
Cornerstones of Plant Protection Policy in Germany
JKI
Act
Good Plant Protection Practise
NAP
Pflanzenschutzgesetz
Gute fachliche Praxis im Pflanzenschutz
Nationaler Aktionsplan zur nachhaltigen Anwendung von Pflanzenschutzmitteln
EC Regulations
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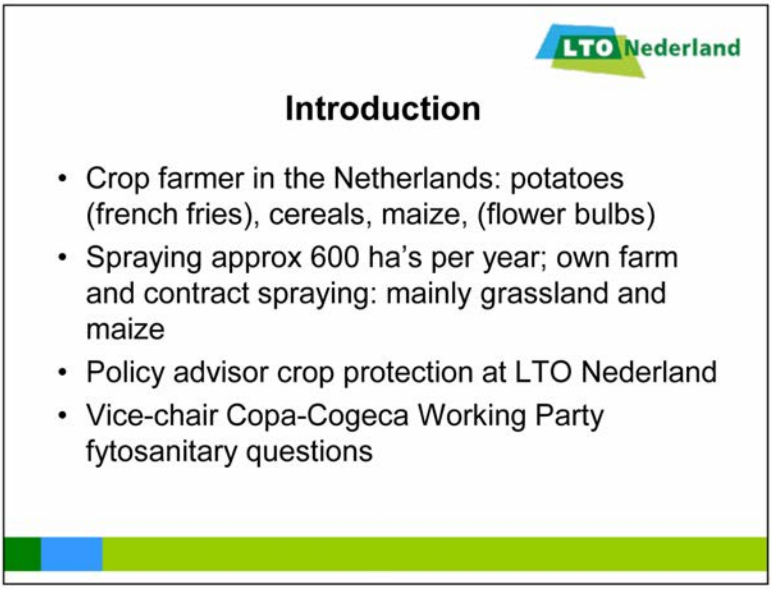
15 years of sprayer inspections in the Netherlands: Benefits for farmers and society

Van Wenum, J.
Farmer, Senior Policy Advisor Crop Protection LTO Nederland & Vice Chair Working Party Phytosanitary Questions, Copa-Cogeca, Postbus 240, 8000 Zwolle, The Netherlands
DOI 10.5073/jka.2012.439.002

In 1997 sprayer inspections were first introduced in the Netherlands by the Product Board for Arable Farming and the Product Board for Horticulture. Farmers and growers at the time realized that careful use of agrochemicals was a prerequisite for maintaining support by regulators and society benefiting both spraying results and the environment. Next to sprayer inspections also spraying licenses were introduced at that time. In the beginning all sprayers were inspected every two years. Since there had not been a testing program before lots of old sprayers where updated or replaced in the early years upgrading the level of spraying significantly.

Later on the frequency of testing was changed to once every three years. Over the years sprayers evolved and spraying practices evolved: low dosage systems became common practice,, low drift nozzles were introduced and more recently GPS is used to support spraying. Next to the technical spraying results and the effect on the environment, especially avoiding spray drift toward waterways, management of residuals on crops (MRL's) has become an important issue in crop protection. This requires sprayers that are in optimal condition especially the optimal distribution of chemicals on crops is essential to avoid MRL exceedances. For a grower checking the distribution features requires specialized equipment that is offered as part of the sprayer testing program. Among other features such as checking the construction and determining the pump capacity this is a highly valued part of the test program.

So whereas in the beginning support from government and society were the reasons for starting sprayer inspections nowadays market demands and certification schemes have become more and more important for testing sprayers.



LTO Nederland

History of sprayer inspections in NL

- "Mandatory" introduction in 1997
- Farmer initiative
- Responsible use of ppp's was needed to tackle criticism from regulators and society
  - Spraying licenses
  - sprayer inspections
- Set up of an independent institute responsible for sprayer inspections (SKL)

LTO Nederland

History of sprayer inspections in NL

Begin period:

- Sprayers tested every two years
- Many old sprayers updated or replaced
- Upgrading quality of spraying equipment

Later on:

- Sprayers tested every three years

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Farmer experience

- Sprayer inspection is a valued part of machine maintenance, important aspects:
  - nozzle testing: distribution of chemicals
  - rearing capacity
  - construction and safety aspects
- Testing is done:
  - At acceptable costs (approx 200 euro)
  - In short time (approx 1 hour excluding necessary repairs)
  - at nearby location (machinery dealer)

LTO Nederland

Farmer benefits

- Up to date equipment in good condition
  - Importance of good chemical distribution features (MRL setting, spraying results)
  - Avoiding environmental risks such as leakage and spray drift
  - Compliant with regulations and certificates (Global Gap etc)

LTO Nederland

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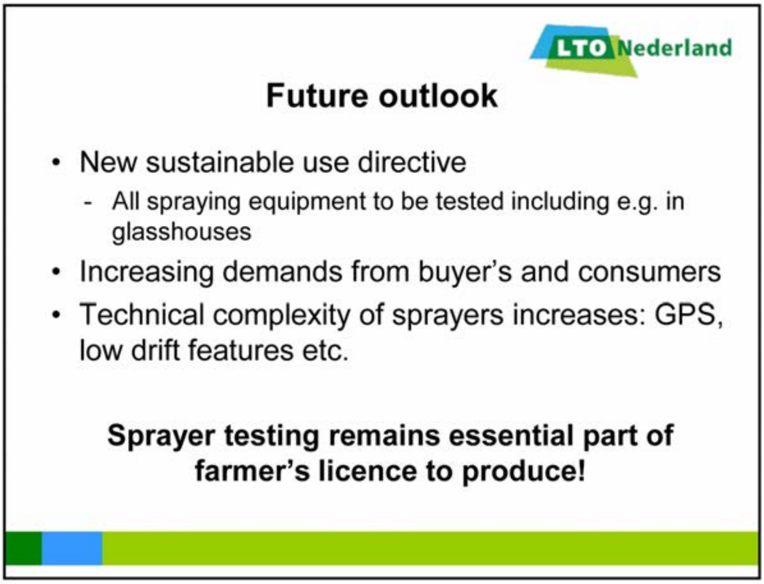
Benefits to society

- Reduction of environmental risks
  - Waterways
  - Ground water
  - Non target plants and insects (bees!)
  - Food safety
- Reduction of risks to residents and bystanders


LTO Nederland
Future outlook
• New sustainable use directive
- All spraying equipment to be tested including e.g. in glasshouses
• Increasing demands from buyer's and consumers
• Technical complexity of sprayers increases: GPS, low drift features etc.
Sprayer testing remains essential part of farmer's licence to produce!

Experiences with and benefits of the inspection of air-assisted sprayers from the fruit- and winegrowers' point of view

Waldner, W.; Knoll, M.
South Tyrolean Extension Service for Fruit- and Winegrowing, A. Hofer-Straße 9/1, 39011 Lana, Italy
DOI 10.5073/jka.2012.439.003

Summary

Until the 1960s pesticides were applied with a spray gun connected to a long hose or directly to the tank and operated by a worker standing on a platform. This technique was gradually replaced by air-assisted sprayers.

The purchase of three sprayer test facilities in 1991 signified the start of a new era in pesticide application:

- The ejection rate of the individual nozzles as well as the distribution pattern of the liquid could be measured and optimized on a vertical test stand by adjusting the nozzles or adding additional ones.
- The ceramic nozzles were replaced by hollow-cone nozzles, which allowed for the first time to calculate the exact amount of liquid per hectare and tree height based on various parameters such as driving speed, spray pressure, number of open nozzles and nozzle output volume. The amount of water was reduced from 500 l/m tree height and hectare to 166 – 100 l.
- The efficacy of the pesticides was increased and spray drift reduced, which brings about economic and ecological benefits.
- Up to the year 1997 sprayer calibration was optional. Since then, a sprayer calibration in 5-year intervals has become a condition for participation in the South Tyrolean IP-programme. This also facilitates the observance of the GobalGAP control points and Compliance Criteria regarding application equipment.

Since 2011 the South Tyrolean sprayer manufacturers and fruit- and winegrowers have been able to measure and optimize the air blast and emission pattern. Thereby we hope to further reduce spray drift and increase the efficacy of the pesticides. A properly calibrated sprayer enables the fruit- and winegrowers to observe more easily the regulations for the distances to residential and public buildings as well as pastures enacted by the South Tyrolean Provincial Government and AGRIOS in 2011.
We trust that the South Tyrolean fruit- and winegrowers will have no difficulties in complying with the Directive 2009/128/EC on the sustainable use of pesticides with regard to application techniques and sprayer calibration.

Introduction

South Tyrol is the northernmost province of Italy and together with the province of Trentino it forms the autonomous region of Trentino – Alto Adige. 80% of the Italian apples come from this region. The apple growers from Trentino supply their marketing operations with almost 600,000 tons, the South Tyrolean growers have produced over 1 million tons annually over the past four years, which makes up more than half of the Italian and over 10% of the total European production. The South Tyrolean apple orchard area amounts to 18,500 ha altogether, which are split up among approximately 6,000 operations and about 10,000 owners.
The South Tyrolean vineyard acreage accounts with approximately 5,300 ha for less than 1% of the total Italian acreage. The annual wine production ranges from 300,000 – 400,000 hl, which makes up only 0.6% of the total annual production in Italy. The South Tyrolean vineyard acreage is divided among about 5,000 operations. Without the aid of strong cooperatives and growers' associations the small South Tyrolean fruit and wine producers would not be able to hold their ground in the modern global markets. Approximately 90% of the apples and 70% of the wine are marketed by cooperatives.
South Tyrol is situated on the south side of the Alps. 64% of the cultivated area is located on elevations higher than 1,500m above sea level. The major part of the agriculturally used area is made up of alpine meadows and pasture land. Only 8.5% of the cultivated area is lower than 800m above sea level and it is mostly used for growing apples and wine grapes.
The South Tyrolean fruit- and winegrowing operations are usually very small. Family operations with about 2.5 – 3ha predominate. Traditionally, each of the approximately 6,000 fruit and wine operations has its own machinery stock consisting of one or two tractors, one or two trailers, a mulching machine, an elevating work platform and a sprayer.

Approximately 2/3 of the winegrowing area are situated on the valley floor, 1/3 is on the hillside. In addition, the orchards of these 2.5 – 3ha small operations are usually dispersed across several locations. Therefore, the sprayers have to be roadworthy and suitable for flat and sloping plots at the same time. Since most operations produce both apples and grapes, the sprayers are used in orchards as well as in vineyards. This has to be taken into consideration when calibrating the sprayers at the testing facilities.

Spring frosts are quite frequent on the valley floor, therefore all orchards are equipped with overhead sprinklers, which are used for frost protection and irrigation.

Nearly half of the orchards are provided with hail nets.

Due to the overhead irrigation and the hail nets the use of tunnel sprayers is impossible in South Tyrol, therefore almost exclusively axial fan sprayers with or without cross-flow fan attachments are in circulation here. The majority of these sprayers are produced by four local sprayer manufacturers.

In the South Tyrolean orchards single rows are the predominant planting system. The average orchard alley is 3 – 3.2m wide and the trees are 3.5 – 4m high.

On slopes the trees are often planted in bed systems, which means that the orchard alleys are sometimes spaced up to 12m apart. Some operations have to use the same sprayer in both single row and bed plantings. This has also to be considered when calibrating the sprayers. Axial fan sprayers with a cross-flow fan attachment are preferred. The sprayer test and adjustment at the vertical test stand serve to achieve a uniform distribution of the spray liquid up to a height of 4m.

In viticulture the oldest and still predominant training system here is the "pergola". 70% of the vineyards are situated on slopes or in hilly areas. The sprayers used in these locations cannot be adjusted at the vertical test stand. In this case we can only check the liquid amount ejected by the nozzles and calculate the pesticide quantity required per metre grapevine canopy height and per hectare, so that neither too much nor too little pesticide is applied. In new vineyards wire trellis systems are preferred, because they are suitable for cross-flow fan sprayers, which can be optimally adjusted to the canopy wall.

Alley widths of 1.8 – 2.2m require a precise calculation of the liquid amount, otherwise too much pesticide per hectare will be used.

Developments in the application technique

Until the 1960s pesticides were applied with a spray gun and a long hose or from a work platform attached to the tank.

Gradually, this application technique was replaced by air-assisted sprayers. As long as trees on vigorous rootstocks with a height of up to 6m had to be treated, axial fan sprayers with a large air volume of up to 70,000 m^3 per hour were indispensable. The fan was not operated by a cardan shaft but by a separate engine, which made the sprayer difficult to manoeuvre.

Sprayer inspection in the South Tyrol since 1991

In 1991 the South Tyrolean Extension Service decided to introduce sprayer inspections according to the Styrian model. We were assisted by Mag. Karl Lind, whose help proved very valuable.

When we bought three sprayer testing facilities in 1992, a new era began for the application of pesticides in South Tyrol. The purchase of the three testing devices was funded by the South Tyrolean fruit and wine industry and they were consigned to the South Tyrolean Extension Service. We gave the testing facilities to three mechanics, who perform the tests on their own behalf. The prices are fixed consensually with representatives of the South Tyrolean fruit and wine industry. At present a sprayer inspection and calibration costs 123 Euros plus 21% VAT. The mechanics are trained by experts from the Extension Service and their services are officially acknowledged by the Department of Plant Protection of the Autonomous Province of Bolzano.

Fig 1. Test bench for the measurement of the flow rate of each nozzle (left) and of the liquid distribution (right).

Sprayer checks are mandatory in the South Tyrol

Initially, the sprayer checks were optional. From 1997 onwards they became mandatory in 5-year intervals for all growers that wanted to participate in the South Tyrolean IP-programme for pip fruit. Now, a sprayer check every five years is a condition for the GlobalGAP certification of our operations. In addition, the GlobalGAP standards demand an accurate calculation of the liquid amount and an annual calibration of the sprayers. At present approximately 95% of our operations meet these requirements. At first sight this seems to be a liability but it brings with it a recompense. Participants in the AGRIOS-programme get direct or indirect EU subsidies of 1,200 Euros per hectare. GlobalGAP certification is a condition for being able to hold one's own in the globalized apple markets.

What is measured during a sprayer test?

The flow rate of each nozzle, the accuracy of the manometer, the liquid distribution, the tractor speed in different gears and the rotation speed of the PTO shaft are checked.
The filters, the tank agitator and the water conducting tubes are optically assessed.
During the inspection defects are, if possible, fixed on the spot. Ideally, only sprayers that have passed the test can leave the testing centre. If the defects cannot be repaired immediately, the sprayer has to be taken to a service station and checked again afterwards.
A complete inspection usually takes 2 hours. In order to avoid long waiting times the grower has to register at the Extension Service or at the sprayer testing centre and to submit his or her personal data, details about the sprayer, the nozzle type, the training systems in the respective orchards or vineyards and the canopy height.
After the tests the results are transmitted via the Internet to a server which can be accessed by the technicians of the South Tyrolean Extension Service. Based on these data we work out together with the grower an instruction sheet on the application of pesticides in his or her orchards and vineyards.
In order to be able to better adjust the air amount of the sprayers to the tree volume and the canopy wall of the vines an air flow testing stand was acquired in 2011.

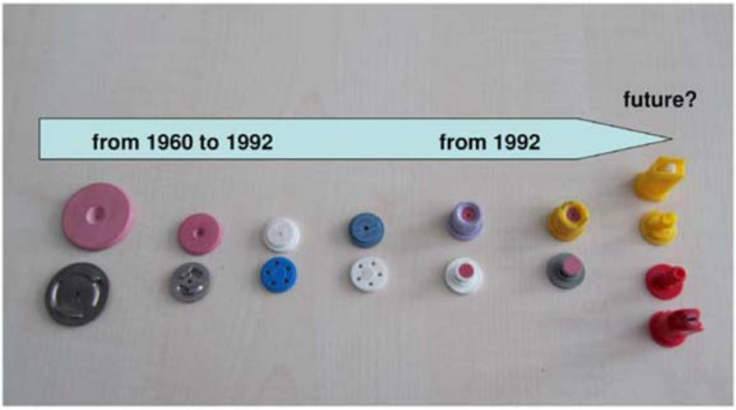


Fig. 2. Nozzles used in South Tyrol for air-assisted sprayers.

Before 1992 most sprayers in South Tyrol were equipped with ceramic nozzles with a small metallic dosing plate. In the course of the sprayer inspections most sprayers were fitted with Albuz ATR hollow-cone nozzles from 1992 onwards, and their air flow is checked every five years. Our next step is to convince all growers to replace at least the three topmost nozzles with drift-reducing air induction nozzles.
At present about 6,000 sprayers are in use in South Tyrol. Most of them are checked every 5 years at the sprayer testing centres. When a south Tyrolean fruit- or winegrower buys a new sprayer, it is customary to stipulate a sprayer test in the sales contract.

Spray liquid amount

We calculate that the water amount required per metre tree height and hectare is 500l. Therefore, if the trees are 3.5m high, 1,750l of water are needed. Nowadays no grower in this area would apply a pesticide in the "normal volume" concentration because it would be too time-consuming, the coverage would be poorer because of the larger droplets and the runoff losses would be too high. By now, the majority of the South Tyrolean growers has adopted low volume spraying with 350 – 580l of water per hectare, which means that the concentration of the spray liquid is five to three times higher.

Project "Low-Loss Spraying".

Since 2011 the South Tyrolean Extension Service has taken an active part in the project "Low-Loss Spraying". We hope that the Italian legislative will acknowledge that this application technique is a drift-reducing measure, as the Austrian and German authorities have already done.
A reliable inspection protocol is absolutely essential for the exact calculation of the liquid amount per hectare. The growers usually need the help of an expert so as not to apply too large or too a small quantity of a pesticide. On the basis of these measurements our technicians can work out together with the growers an instruction sheet that is custom-tailored to their orchards or vineyards. In accordance with the planting systems used in the operation it contains exact details about the optimal liquid amount per hectare or for the size of the individual orchards or vineyards, the ideal driving speed, the number of nozzles to be opened, the pressure and the rotation speed.

Reducing drift – a must

Fig. 3. Applying pesticides in urban areas is a sensitive issue.

Since the beginning of this year the South Tyrolean growers have been faced with a new challenge. The South Tyrolean local government has issued new guidelines regarding the distances to be kept to neighbouring properties when applying a pesticide. They are binding for a community if it wants to issue a regulation for its territory. A similar regulation was included in this year's IP-guidelines for pip fruit in order to minimize drifting from orchards into nearby pastures and area under grain or herb cultivation.

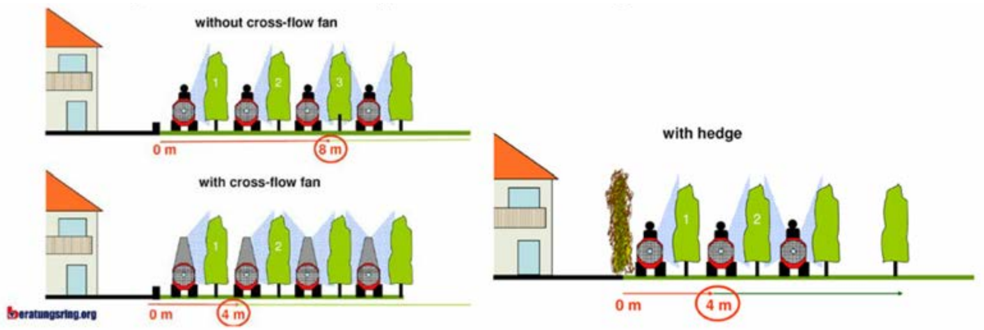


Fig. 4. Regulations regarding the distances to residential and public areas in South Tyrol.

These guidelines and regulations had become necessary because not every grower exercised enough care when applying pesticides with an air-assisted sprayer near residential areas, public facilities, pastures and grain or herb fields. The guidelines provide that when spraying an orchard with an axial fan sprayer the last 8m along the orchard borders have to be treated in the direction of the interior of the orchard. If a sprayer with a cross-flow fan is used, however, the distance can be reduced to 4m. If the orchard is bounded by a hedge, the distance from the borders within which the pesticide has to be sprayed towards the interior is also 4m.

Our IP-guidelines for pip fruit also require that from 2012 onwards if a new orchard which borders on a meadow, or a grain or herb field is planted, a minimum distance of 3m from the boundaries has to be observed and at least 5m have to be calculated for the headland, where the tractor is turned around.

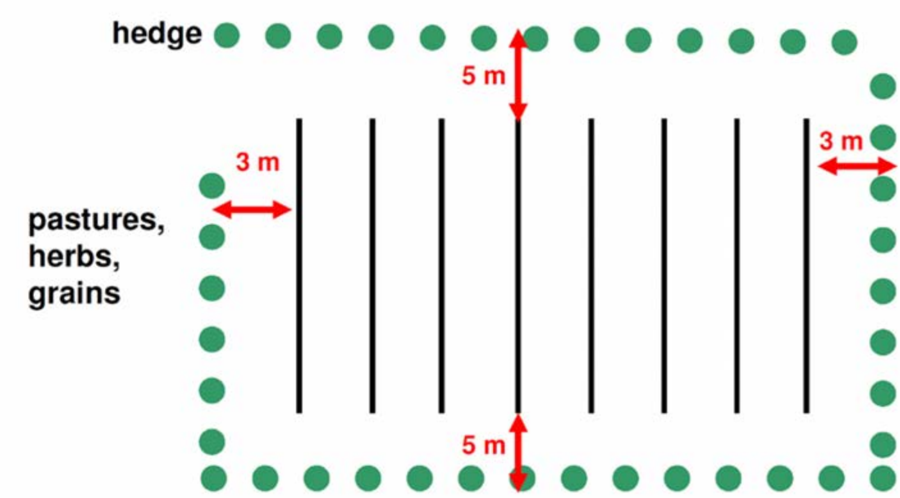


Fig. 5. Distances to pastures and areas under grain and herbs cultivation.

Additionally, a hedge of at least 2m in height has to be planted along the orchard border. New sprayers which are used next to private gardens or public facilities have to be fitted with a cover plate.
How is this recorded? The test centres attest in the inspection protocol that a sprayer is equipped with drift-reducing devices.

Conclusions

- Technical defects which are detected during the inspection are, if possible, repaired immediately. This has considerably improved the technical condition of the sprayers in circulation in South Tyrol today.
- In the consultations before and after the sprayer inspection we manage to convince most growers to switch to low volume spraying. This has increased the coverage rate of the foliage and therefore the efficacy of the pesticides and reduced losses due to runoff.
- Almost all South Tyrolean sprayers feature Albuz ATR hollow-cone nozzles. This allows an accurate calculation of the liquid amount per acreage and tree height based on various parameters.
- By using a vertical test stand we managed to adjust the liquid amount better to the tree height and canopy volume in the individual orchards.
- As of recently it has also become possible to measure the air flow. In this way we hope to further increase the efficacy of the pesticides and decrease drifting.
- We will try also in future to make sure that our sprayer inspection programme keeps pace with the latest technological advances. Therefore we are very pleased that you have chosen South Tyrol as venue for this 4th SPISE-workshop and hope that this will provide us all with stimuli to further improve our spray application technique and sprayer testing methods. Finally, I would like to appeal to the Italian authorities to integrate the application technique of "low-loss spraying" into the National Action Plan.

Actual survey on the actions of the countries in Europe to implement the inspection system of sprayers concerning the Directive 2009/128/EC

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Summary
With a view to the SPISE 4 workshop at the end of the year 2011 a further survey in the European Member States (MS) and other countries in Europe was carried out. The aim of this survey was to compile information concerning the actual situation of sprayer inspection and the planning for the implementation of an inspection system following the Framework directive. The responsible colleagues of all involved countries got a short questionnaire where they updated the filled data and gave new information.

1. Introduction
On the occasion of the previous SPISE workshops in the year 2004, 2007 and 2009 similar surveys were carried out. With that information it was pointed out that the situation regarding sprayer inspections in the Member States and other European countries at first was marked by great differences. But in view of the publishing of the DIRECTIVE 2009/128/EC more and more countries started an inspection system.
With this actual survey the colleagues were asked for updating the data regarding the inspection of field and air-assisted sprayers, and for the first time for all kind of sprayers which are mentioned in article 8 of the Directive (as foggers, hand-operated and handheld sprayers, pesticide application equipment not used for spraying, knapsack sprayers and spray equipment mounted on aircrafts or trains). In detail the colleagues were asked for data regarding:

1. the number of sprayers in use,
2. the kind of data basis regarding the numbers of sprayers,
3. and if there will be established a sprayer register in future,
4. the obligation of the inspection.

Over that there are some further questions regarding

1. the exemption of kinds of sprayers and if this is following a risk assessment,
2. the average inspection costs,
3. the amount of inspected sprayers in 2009 and 2010,
4. the inspection interval,
5. the procedure for brand new sprayers,
6. the source for the requirements,
7. the procedure for sprayers where a defect is stated,
8. the prohibition of use if a sticker/test report is missing ,
9. the bodies responsible for implementing the inspection system (as requested by article 8, paragraph 6 of the Frame Work Directive),
10. a picture or scheme of a sticker,
11. the execution by authorized workshops or official teams,
12. the number of workshops or teams and the existence of a database where authorized workshops are listed,
13. the subsidies for the implementation of inspection sites from the government,
14. the measuring system concerning the cross or vertical distribution,
15. the offer or realization of adjustments and/or calibrations during the inspection procedure.

Herewith I would like to take the opportunity to thank all answering colleagues for the fruitful cooperation and for their contributions. Especially the compilation of the number of sprayers in use and the number of yearly carried out inspections was combined with some problems due to the fact that most countries do not maintain any central register in this connection.

2. 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.

Tab. 1. Inspection of field sprayers in the European Countries

Country	Number of sprayers in use	Number of sprayers inspected (average 2004-2006)	Number of sprayers inspected (average 2006-2008)	Number of sprayers inspected (average 2009-2010)	After how many years the inspection must be repeated	Average inspection cost (Euro) from…to...	After how many years the first inspection of brand new sprayers is scheduled	Inspection carried out by workshops (W) or official teams (T)
Austria	40.000	9.367	10.529	7.000	3	120	3	W
Belgium	18.300	6.344	6.344	5.842	3	70-160	3	T
Bulgaria	4.960	0	0	0	5	70-160	5	W
Czech Republic	7.163	1.150	1.437	1.419	5	100-350	5	W
Denmark	20.000	151	61	0	3	220-600	3	?
Estonia	1.500	218	234	248	3	48-96 + transp.	3	W
Finland	15.000	0	0	2.617	5	80-200	5	T
France	150.000	0	0	14.650	5	150-250	5	W
Germany	130.200	73.090	72.806	66.095	2	60-400	0.5	W
Greece	48.736	0	0	18	3	?	5	?
Hungary	35.000	0	0	0	0	?	?	?
Italy	200.000	2.300	2.333	3.660	2 to 5	40-150	after 2016 before delivery	W
Latvia		0	0	0	3	?	5	T
Lithuania	15.000	0	0	1.043	5	30-120	before delivery	W
Luxembourg	1.090	421	805	224	3	120-300	3	W
Netherlands	12.347	5.751	6.580	4.144	3	150-225	3	W
Norway	16.000	1.950	1.000	439	5	200-350	3	W
Poland	306.777	55.941	46.465	49.610	3	15-30	3	W
Portugal	28.000	0	0	200	5	35 + transp.	5	?
Romania	19.533	0	0	0	5	?	5	?
Serbia	20.000	0	0	14	2	100-250	2	T
Slovakia	3.500	605	685	597	5	160-350	5	W
Slovenia	16.078	7.172	10.053	6.625	2	40	0.5	T
Spain	100.000	300	1.433	0	4	120-150	5	Both
Sweden	14.500	1.700	1.750	1.250	2	~ 400	2	W
Switzerland	13.300	2.980	3.530	3.125	4	60-90	1	W
United Kingdom	47.500	11.424	13.447	14.700	1	150-230	before delivery	W

Tab. 2. Inspection of air-assisted sprayers in the European Countries

Country	Number of sprayers in use	Number of sprayers inspected (average 2004-2006)	Number of sprayers inspected (average 2006-2008)	Number of sprayers inspected (average 2009-2010)	After how many years the inspection must be repeated	Average inspection cost (Euro) from…to…	After how many years the first inspection of brand new sprayers is scheduled	Inspection carried out by workshops (W) or official teams (T)
Austria	20.000	6.000	6.500	5.500	3	120	3	W
Belgium	1.681	729	729	536	3	76	3	T
Bulgaria	1.665	0	0	0	5	70-160	5	W
Czech Republic	1.372	74	280	266	5	100-250	5	W
Denmark	?	0	0	0	3	?	3	?
Estonia	some	?	11	?	3	?	3	W
Finland	20	0	0	0	5	?	5	T
France	100.000	0	0	3.400	5	130-240	5	W
Germany	42.000	20.957	18.679	19.844	2	60-180	0.5	W
Greece	103.857	0	0	0	3	?	5	?
Hungary	15.000	0	0	0	0	?	?	?
Italy	400.000	5.967	4.933	7.320	2 to 5	40-150	after 2016 before delivery	W
Latvia	?	11	14	?	3	?	5	T
Lithuania	100	8	8	20	5	35-85	before delivery	W
Luxembourg	227			102	3	100-250	3	W
Netherlands	1.875	831	671	588	3	120-170	3	W
Norway	1.000	55	50	1	5	?	3	W
Poland	22.111	3.843	3.194	3.579	3	15-30	3	W
Portugal	28.000	180	430	610	5	35 + transp.	5	?
Romania	5.680	0	0	0	5	?	5	?
Serbia	?	2	2	10	2	100-250	2	T
Slovakia	500	80	102	108	5	130-250	5	W
Slovenia	6.821	2.881	2.958	2.739	2	40	0.5	T
Spain	200.000	1.133	933	?	4	120-150	5	Both
Sweden	250	50	50	0	2	~ 400	2	W
Switzerland	3.000	675	769	841	4	60-90	1	W
United Kingdom	2.500			850	1	180	before delivery	W

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

	Austria	Belgium	Bulgaria	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Italy	Latvia	Lithuania	Luxembourg	Netherlands	Norway	Poland	Portugal	Romania	Serbia	Slovakia	Slovenia	Spain	Sweden	Switzerland	United Kingd.
1 	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2 	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
3 	x	x	x	x	x	x	x	?	x			x	x	x	x	x	x	x	x	x	x	x			(x)		x
4 	x	only >2 nozzles	x	x	x		x	?	x		x	only glass houses	x	x	x	x	x	x	x	x	x	x		only > 100l	(x)		
5 	x	x	x	x		x	x	?	x			x	x	x	x		x	x	x	x	x	x			(x)		x
6 							(x)												x		x						
7 							(x)	?											x		x			(x)	(x)		
8 	x	x		x	x		x	x	x		x	?	x	x	x	x	x	x	x	x	x	x			(x)		x

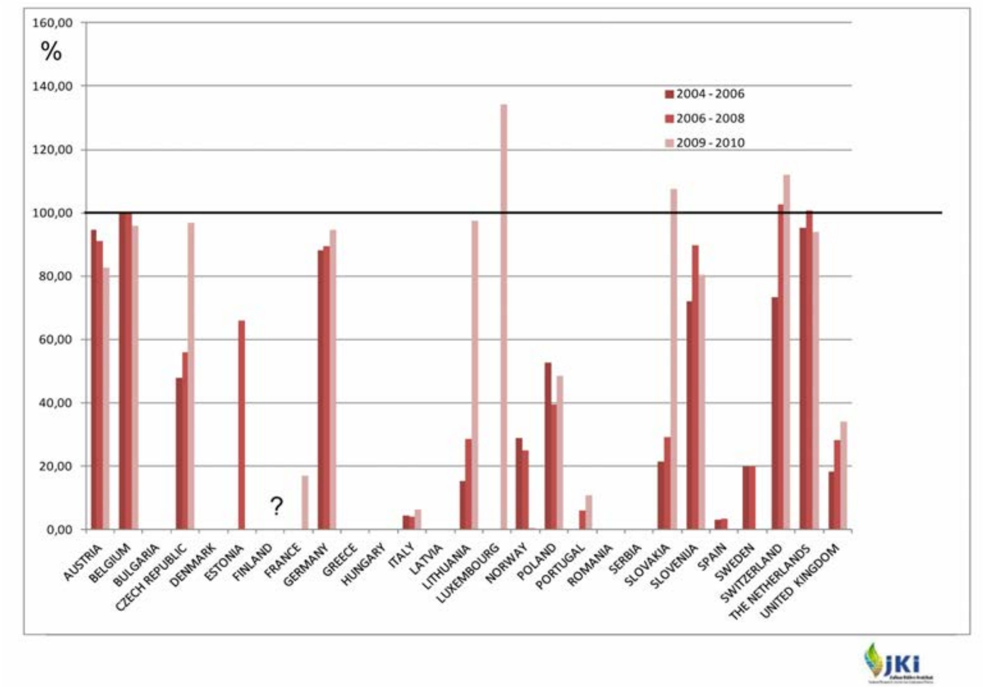
Exemption follows a risk assessment

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



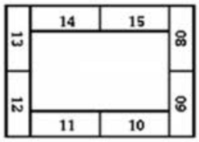
Concerning the scheduled time of the first inspection of brand new sprayers the answers differs a lot. Due to the fact that some defects (e. g. leakages or internal dirtying) occur directly from the production, Italy, Lithuania and United Kingdom decided that the sprayers shall be inspected before the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

Austria	Federal states of Austria	
Belgium	Federal Agency for the Safety of the Food Chain (FASFC) - Boulevard du Jardin Botanique 55 1000 Brussels http://www.afsca.be	
Bulgaria	Technical Control Inspectorate, address: Tzar Boris III 136 blvd., Sofia 1618, e-mail: kti@mbox.contact.bg	
Czech Republic	Ministry of Agriculture through the SPA	
Denmark	Danish Enironmental Protection Agency, Strandgade 29 DK - 1401 Copenhagen K	?
Estonia	Ministry of Agriculture, Lai 39/41, 15056 Tallinn, Estonia, and Agricultural Board, Teaduse 2, 75501 Saku, Harju county, ESTONIA	
Finland	The Safety and Chemicals Agency (TUKES), P.O. Box 66, FI-00521 Helsinki, Finland	
France	MINISTERY OF AGRICULTURE / GIP PULVES (MONTPELLIER) GIP PULVES, 361 rue Jean François Breton BP 5095 – 34196 MONTPELLIER Cedex 5	

Germany	Plant Protection Services of the Federal States	
Greece	Ministry of Rural Development And Food (Department of Agricultural Mechanization)	?
Hungary	?	?
Italy	ENAMA (Ente Nazionale per la Meccanizzazione Agricola), National Technical Workgroup, Regional Bodies	Actually national sticker isn't available. Successful inspection "Attestato di funzionalità". This document contains the informations: type of sprayer, any identifying marks, name o the farm, date, signature of the technician, name of authoriz
Latvia	State Plant protection Service of Latvia	?
Lithuania	State Plant Service under the Ministry of Agriculture, Ozo str. 4A, Vilnius	?
Luxem-bourg	ASTA sevice agri-environnement www.asta.etat.lu	
Netherlands	SKL, Agro Businesspark 24, NL-6708PW Wageningen, the Netherlands	

Norway	Norwegian Food Safety Authority, Felles postmottak, Postbox 383, N-2381 Brumunddal.	
Poland	Inspection of Plant Health and Seed (Państwowa Inspekcja Ochrony Roślin i Nasiennictwa) www.piorin.gov Main Inspectorate of Plant Health and Seed Inspection	
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 Wather 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 responsability to organize the inspection procedure on their area.	 

Sweden	none yet, probably the Swedish Board of Agriculture	?
Switzerland	Schweizerischer Verband für Landtechnik, Postfach 55, CH-5223 Riniken	
United Kingdom	AEA, NSTS, 62 Forder Way, PE7 8, Peterborough	

3. Conclusions

Summarising all data, it can be stated that the involved countries reported an existence of nearly 2.25 millions of field and air-assisted sprayers (2009: 2.5 millions). 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.

Session 1: Inspection at regular intervals – Inspection of new equipment

Introduction paper

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May I draw your attention to the fact, that an EU regulation (e.g. Regulation (EC) 1107/2009 – Placing of Plant Protection Products) takes direct effect, i. e. it is legally binding in all Member States. As a contrast an EU directive does not take direct effect, i. e. it has to be implemented in the Member States by national legislation first.

Round table	Art.8 128	Objects and benefits of the obligatory inspection in the EU	Further regulations acc. Principles of subsidiary legal regulations	technical specifications
1	§1&2	MS ensure PAE inspection Regular intervals Deadline New PAE	Conducting inspections Regular inspecting intervals Deadlines Brand new PAE	WS approval/monitoring/rejection Inspection regulation Quality assurance system How to deal with new PAE? How to deal with minor defects?
2	§3	Derogation & exemptions Different timetables & intervals	Exemptions inspection Diff. timetables & intervals Listing in the NAP Training of operators	Risk assessment Assessment of scale of use Training of operators
3	§4	Inspection acc. Annex II	Harmonized standards	How to inspect without EN standards
Even. Progr.	-	Calibration, adjustment, DRT Poster Exhibition	-	Added values by - sprayer calibration - adjustment to the canopy structure - Drift reducing Techniques (DRT)?
-	§5	Regular calibration & checks	Binding user to conduct regular calibration & checks	SWG proposal available Implemented in Eurogap certification
4	§6	Designate Bodies, Certificate systems, Mutual recognition	Designate bodies… Establish certificate systems	Certificate systems consists of sticker and test report SWG proposal available
5	-	Training	Well trained inspectors Statistics reporting	Specification of theoretical+ practical training (content, basics, examination, documents, ppts) Maintenance & repairing
6	-	Miscellaneous	Prohibition of use, offences PAE without valid sticker must not be used	

Fig. 1. shows the relation between EU/CEN/Federal and States regulations on the official inspection of sprayers in Germany.

The directive 2009/128/EC does not take direct effect and is implemented by the German Plant Protection Act:
The Federal Ministry of Food , Agriculture and Forestry (BMELV) is empowered to issue ordinances.
The Federal States (FS) are empowered to requiring holders/owners to have plant protection equipment (PPE) already in use tested and lay down details of this procedure …
They may also stipulate that testing shall be carried out by officially recognized inspection workshop and may lay down the requirements to met for approval, loss of approval, …
The Federal states may delegate these powers to state authorities (PPS) …

In the ordinance further aspects are specified:
Field crop sprayers and bush in tree crop sprayers have to be inspected by an official recognized inspection workshop at intervals of two calendar years.
PPE which can be carried by a person is not subject to obligatory inspections …

For uniform enforcement of PPE inspection in the Federal States (FS) a workshop approval degree es recognized by the FS and regulates the

- approval,
- power of the inspection workshops,
- obligations of the inspection workshops and
- termination of approval/cancellation/withdrawing.

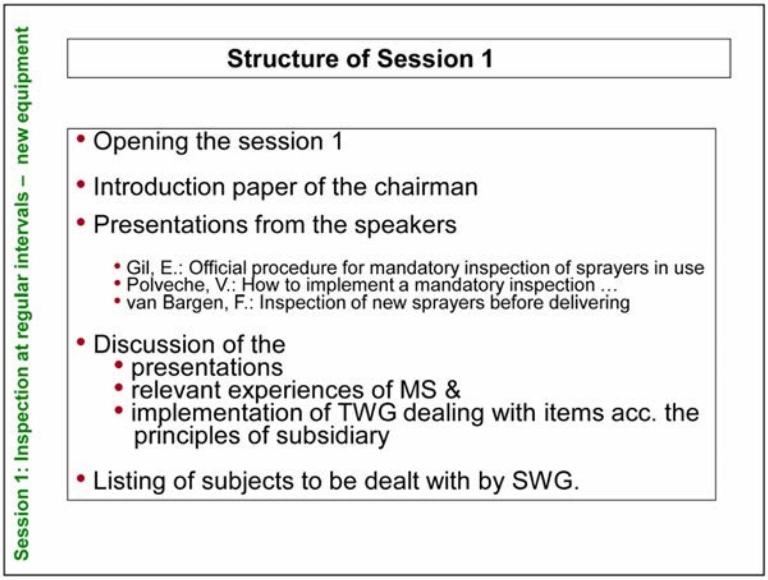
For carrying out the PPE-inspection according to the plant protection act an inspection regulation degree is recognized by the FS and regulates the

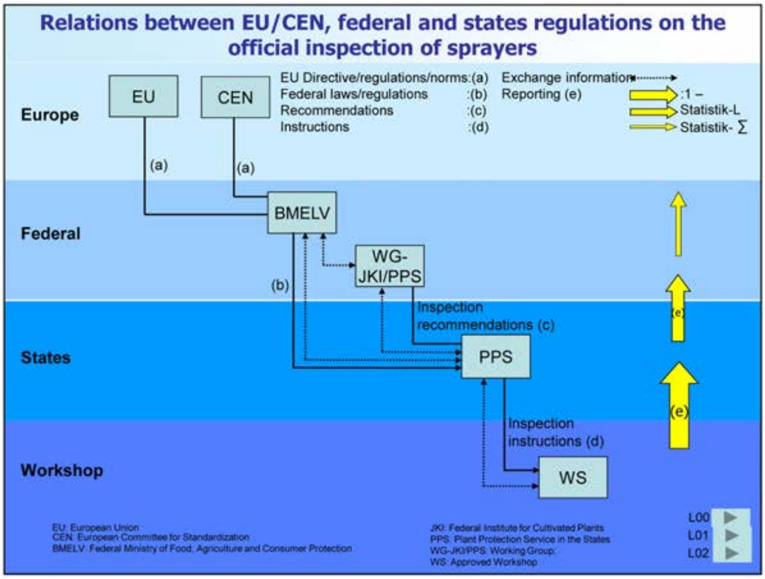
- procedure of inspection,
- inspection report,
- procurement of inspection stickers and
- training of inspection personnel.

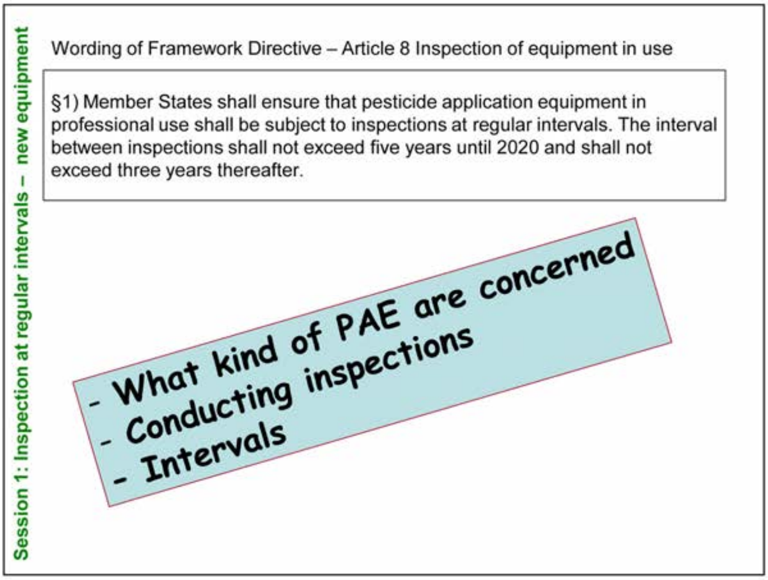
The whole procedure of sprayer inspection in Germany is described in the information package on the following website: spise.jki.bund.de.

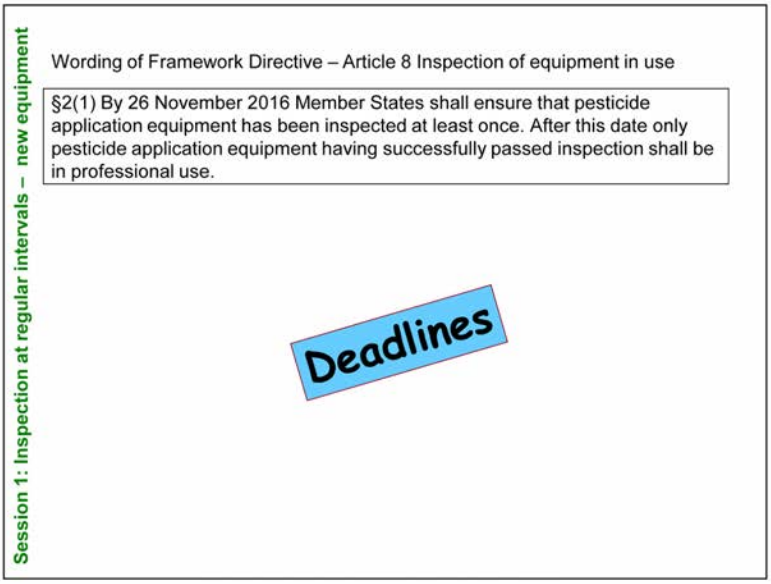
According to the principles of subsidiarity the following items have to be specified:

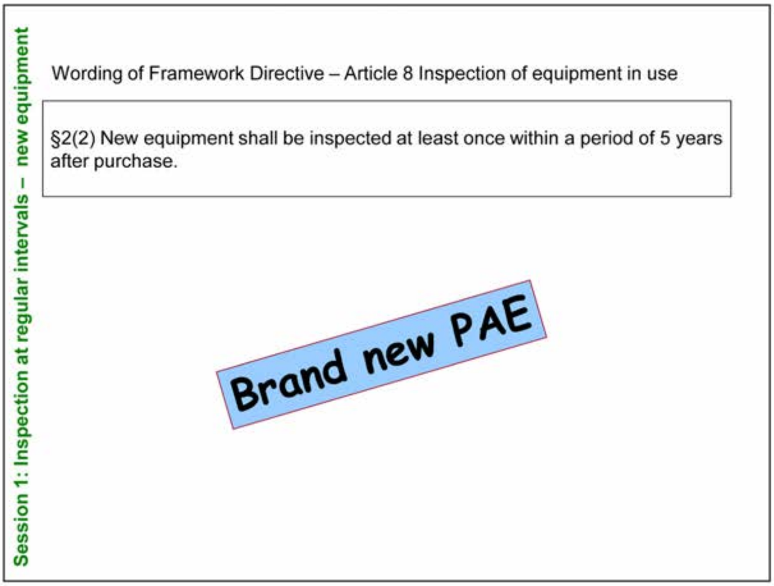
- workshop approval, monitoring, rejection – see spise.jki.bund.de,
- inspection regulation,
- quality assurance system,
- how to deal with new PPE,
- how to deal with minor defects.

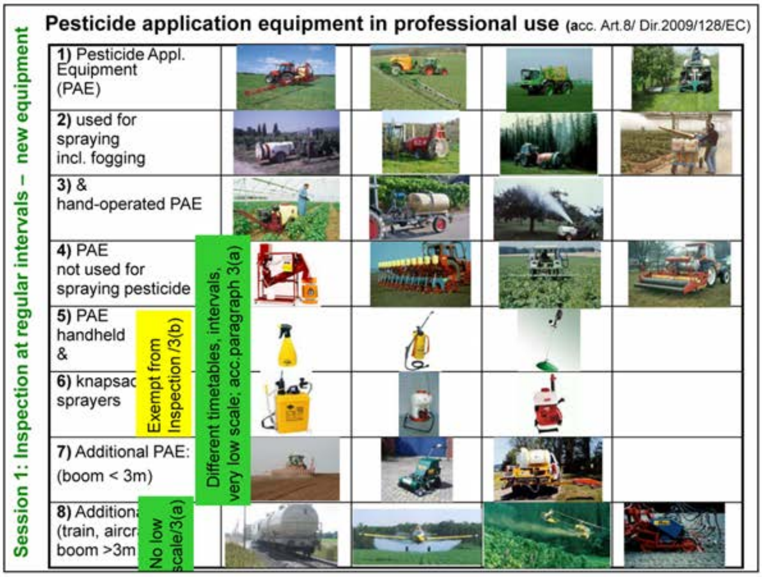


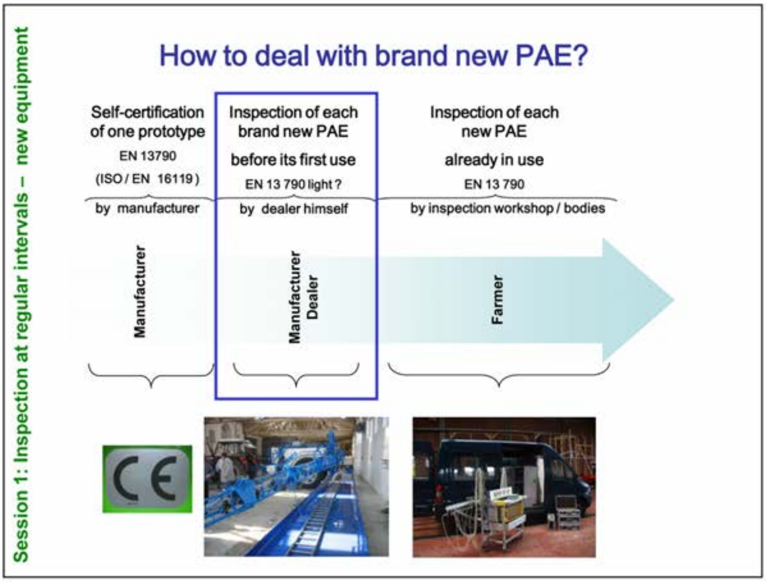

Relations between EU/CEN, federal and states regulations on the official inspection of sprayers
Europe
EU
CEN
EU Directive/regulations/norms: (a)
Federal laws/regulations :(b)
Recommendations :(c)
Instructions :(d)
Exchange information
Reporting (e)
:1 –
Statistik-L
Statistik- Σ
(a)
(a)
Federal
BMELV
WG-JKI/PPS
(b)
States
Inspection recommendations (c)
PPS
Inspection instructions (d)
Workshop
WS
(e)
(e)
EU: European Union
CEN: European Committee for Standardization
BMELV: Federal Ministry of Food, Agriculture and Consumer Protection
JKI: Federal Institute for Cultivated Plants
PPS: Plant Protection Service in the States
WG-JKI/PPS: Working Group:
WS: Approved Workshop
L00
L01
L02


Session 1: Inspection at regular intervals – new equipment
Wording of Framework Directive – 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.
- What kind of PAE are concerned
- Conducting inspections
- Intervals


Session 1: Inspection at regular intervals – new equipment
Wording of Framework Directive – Article 8 Inspection of equipment in use
§2(1) 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.
Deadlines


Session 1: Inspection at regular intervals – new equipment
Wording of Framework Directive – Article 8 Inspection of equipment in use
§2(2) New equipment shall be inspected at least once within a period of 5 years after purchase.
Brand new PAE


Session 1: Inspection at regular intervals – new equipment
Pesticide application equipment in professional use (acc. Art.8/ Dir.2009/128/EC)
1) Pesticide Appl. Equipment (PAE)
2) used for spraying incl. fogging
3) & hand-operated PAE
4) PAE not used for spraying pesticide
5) PAE handheld &
6) knapsac sprayers
7) Additional PAE: (boom < 3m)
8) Addition (train, aircr boom >3m
Exempt from Inspection /3(b)
Different timetables, intervals, very low scale; acc.paragraph 3(a)
No low scale/3(a)


Session 1: Inspection at regular intervals – new equipment
How to deal with brand new PAE?
Self-certification of one prototype
EN 13790
(ISO / EN 16119)
by manufacturer
Inspection of each brand new PAE
before its first use
EN 13 790 light ?
by dealer himself
Inspection of each new PAE
already in use
EN 13 790
by inspection workshop / bodies
Manufacturer
Manufacturer
Dealer
Farmer

Session 1: Inspection at regular intervals – new equipment

How to deal with brand new PAE?

Inspection of each brand new PAE

before its first use

EN 13 790 light ?

by dealer himself

Manufacturer

Dealer

The inspection of brand new PAE before they were taken into use is

- very advantageous because this guarantees that new PAE also fulfils the requirement of ISO/EN 13790 (ISO/EN 16119)
- without tear & wear and therefore a reduced content of requirements should be applied

Session 1: Inspection at regular intervals – new equipment

How to deal with brand new PAE?

Proposal: Inspection of brand new sprayers (see pp v. Bargen)

- field sprayers -

For testing brand new equipment only the features related to

- pump
- pipe system
- nozzles

shall be applied.

The results of the test shall be described in a test report to be written according to the sample in EN 13790.

Session 1: Inspection at regular intervals – new equipment

How to deal with minor defects?

Proposal: Definition of minor defects
- field sprayers -

The CEN/TC144/WG3 will not define minor defects, but
- the EC/DG Sanco is very interested to keep the inspection procedure as practicable as possible
- DE and other MS have still some positive experiences
- a proposal is submitted and should be further developed by a new TechnicalWorkingGroup (TWG)

.

Session 1: Inspection at regular intervals – new equipment

Prospects

– The Directive 2009/128/EC provides the frame for inspection of PAE in the MS, but

– further regulation acc. to the principles of subsidiary have to be developed by the MS amongst themselves

– this enables the MS to implement these stipulations taking their own experiences & situations into account

– the SPISE4 workshop should invite colleagues to participate in these **TWG** to consider all experiences and competences in their proposals

Discussion of the presentations/relevant experiences of Member States (MS)

- Member States (MS) are intensively engaged to implement a mandatory inspection.
- France considers a more central administration, whereas Spain delegates the responsibility to the regions. In both Member States the inspection is (or will be) conducted by approved inspection workshops, while the general government reserves for the control- and monitoring responsibilities.
- The boom sprayers and air assisted sprayers are in the central focus of inspection.
- How the exemptions (different timetables and inspection intervals) according article 8.3 will be applied by the MS, is currently inexplicit.
- The mutual recognition of the inspection between MS is to date not relevant.
- As a replacement for the missing harmonized norms, the EN 13790 is recommended for temporary use.
- Quality measurements (audits …) have to be developed.
- The participation of farmer/grower should be guaranteed during the inspection process in order to increase the benefit of the action
- In the case of "minor defects" and "brand new pesticide application equipment (PAE)" a special coordination is needed.
- Mandatory training course for inspectors should be harmonized among the EU members.
- Differences on training system lead to differences on inspection procedure/level/exigencies, with great consequences for the user.
- Differences on inspection procedure, equipment, training,… should be avoided among different regions of EU members.

Implementation of a technical working group for developing a common proposal

- How to deal with minor defects? No clear position.
- How to deal with brand new PAE? No clear position.
- It is recommended to implement a technical working group (TWG) for developing common proposals (minor defects, brand new sprayers).

The official procedure for mandatory inspection of sprayers in use in Spain. How to deal with regional autonomous authorities.

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Summary

After the official publishing of 2009/128/CE Directive, the Spanish Ministry of Agriculture, Food and Environment started to develop the national law (Real Decreto) to implement the EU mandate, specifically for those aspects concerning Article 8. This work has been developed in collaboration with some experts from different Spanish local governments (CCAA) and universities. In order to have accurate information about the total sprayers to be inspected in the established time, a new Spanish law (RD 1013/2009) was published with the mandate to register all the sprayers in use. Farmers have had the responsibility to arrange this administrative process in their local government (Official Register of Agricultural Machinery). Once the law will be published the MARM will coordinate the inspection procedure arranged individually for every one of the 17 local authorities (CCAA) through the nominated National Reference Laboratory (NRL). This laboratory will be in charge to harmonize and check the inspection method, validate documents and act as a referee, if needed, of the activities developed by the inspection units. Those inspection units (ITEAF) will be officially recognized by the CCAA and will accomplish the established requirements in the new national law including the particular aspects included by CCAA. Technical requirements of ITEAF must be in accordance with those reflected in the national law. Regarding the capability of inspectors, a complete 40 hours training course has been established as a mandatory previous requirement. Those courses (theoretical and practical) will be delivered by Universities and Research Centers directly related with the subject. For this purpose a detailed Inspection manual has been edited to be published together with the national law. This paper presents the actual situation and the encountered problems during the process of development of the law, and how the inspection procedure has been arranged in all around the country.

Introduction

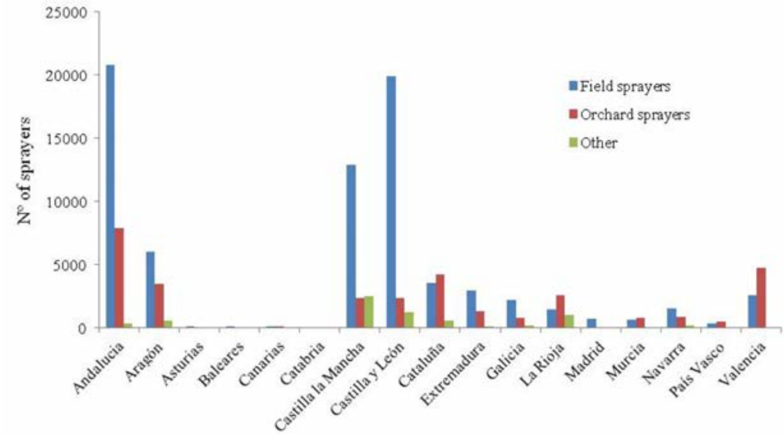
After publication of 2009/128/CE Directive for a Sustainable Use of Pesticides on October 2009, and according the perceptive procedure, all the MS started their administrative process in order to achieve the mandatory transposition of such as that EU mandate. Different purposes have been arranged on every single MS. In case of Spain, the Ministry of Agriculture started the process by arranging two different Spanish Laws: one specifically related with the procedure for the inspection of sprayers in use, and other for the complete management of all the other chapters included in the EU Directive. The first one (RD 1702/2011) has been recently officially approved and published (December 9th 2011) and lies with all aspects, procedures, deadlines and specifications to be followed by the different local authorities in Spain, with the objective to accomplish with the mandatory due to inspect all the sprayers in use by December 2016. The second one, including all the other aspects relative to the ED Directive, is at this time in the last process of official review and is expected to be published before the end 2012. This described scheme represents the structure and way of action of the Spanish National Action Plan to be followed during the next four years.

How many sprayers must be inspected in Spain?

This is the first question to be solved, prior to arrange the inspection procedure itself. At different international platforms, and based on experience, a general data of about 300.000 sprayers has been managed. But unfortunately this is a not official data. For this reason, on July 2009 the Spanish government published a mandatory law (RD 1103/2009) with the purpose to create an official register of all sprayers in use in Spain. This requirement has been established as a mandatory prior to attend the inspection procedure. This information becomes a key point for the local governments in order to arrange the inspection procedure, establishing the adequate number of inspection workshops (ITEAF) as well as the number, placement and inspector's training units.

Two years after the publication of the mandatory registration law, Fig.s on number of sprayers indicate that only about 38% of the expected sprayers (116053 were registered). Regarding the distribution according the type of sprayers, 65.7% has been classified as orchard sprayers, 27.9% field sprayers and 6.4% as others (including hand held sprayers, pneumatic sprayers…). Also important is how the sprayers in use in Spain are distributed among the 17 regions, with big differences both in terms on number and type (Fig. 1).

Fig. 1. Number of sprayers in use and distribution among the 17 regions (official data March 2012)



One of the first consequences of this uneven distribution is the poor relation between number of sprayers and use of plant protection products (PPP). As is very well known, the most intense use of PPP on Mediterranean area is related with vegetable and fruit production, either outside or in greenhouses. In case of Spain, those productions are mainly based all along the Mediterranean coast, which include from vineyard and fruit production in the north (Catalonia) to the intense vegetable productive area in greenhouses in the south (Andalucía), placing citrus production in the middle part (Valencia). So, a comparative analysis between use of pesticides (Gil, 2006) and sprayer's distribution is shown in Fig. 2. Only 39% of sprayers in use are based on 25% of productive area, where more than 75% of Spanish PPP use is registered. On the other side, 61% of sprayers in use are disseminated in a great area with low pesticide pressure. This fact should be considered for the local authorities at the time to arrange the whole procedure of official inspections. Seems logic that the most intense sprayers' use, the most interesting the inspection procedure.

Fig. 2 More than 75% of PPP use in Spain is concentrated in less than 25% of productive area in Mediterranean coast (left), where only 38% of sprayers have been registered (centre), while the great part

of sprayers in use (nearly 7%) are disseminated in the three biggest regions in centre Spain (Castilla-León, Castilla La Mancha and Andalucía).

Inspector's training courses and number of inspection workshops

Due to the characteristics of the Spanish legislation, a Member State with 17 autonomous regions, the responsibility of the arrangement of the inspection procedure below to the local authorities. Since the Spanish Government has published on the official journal the Spanish law concerning the inspection of sprayers in use, the 17 regional governments (CCAA) must implement the procedure in order to accomplish the mandate established by the EU Directive. The official procedure has been established according the flow chart shown in Fig. 3. Once the Spanish Ministry of Agriculture has delivered the official law, every single local authority must design the responsible institution in charge of the inspections. This institution must be arrange, among other minor aspects, the number and placement of inspection workshops, the inspector's training scheme and the official recovery of data concerning their area of responsibility. This structure based on autonomous territories presents, in some cases, certain difficulties in order to guarantee a homogeneous and harmonized.

One of the first problems to be solved is related with the total number of workshops needed to achieve the EU mandate before the end 2016. For this purpose, and based on the official registration data and expecting the achievement of around 300.000 sprayers in use in the whole country, a prospective exercise has been developed. Assuming an intense period of 6 months of sprayer's inspection on every individual workshop (it is not realistic to predict activities during the critical agricultural periods as spraying time, seeding or harvesting, i.e.) and based on a maximum number of inspections per day (around 6), table 1 shows the prediction of total number of inspections workshops distributed among the regions. Prospection has been made also with the premise of at least one inspection every third year, following the mandatory procedure included on the Spanish law. This fact means that, at least 25% of the sprayers should attend 2 inspections during the period from 2012 (October) and 2016 (December).

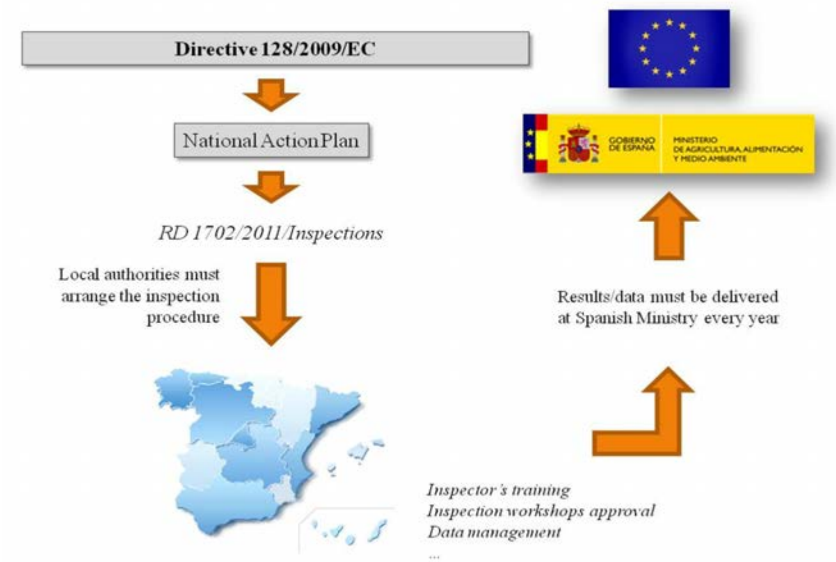


Fig. 3. Official procedure for the inspection of sprayers in use in Spain. The system involves directly all the local authorities.

Tab. 1. Prediction of number of inspection workshops and training facilities. Distribution among the regions

CCAA	Field sprayers	Orchard sprayers	Other	Total	Total expected	T+25%	Yearly	Monthly[1]	Daily	N° ITEAF[2]	N° ITEAF directors	N° Technicians	N° training courses[3]
Andalucia	20798	7928	396	29122	72805	91006	22752	3792	190	32	32	47	3.9
Aragón	6022	3459	600	10081	25202.5	31503	7876	1313	66	11	11	16	1.4
Asturias	137	44	37	218	545	681	170	28	1	0	0	0	0.0
Baleares	140	60	13	213	532.5	666	166	28	1	0	0	0	0.0
Canarias	172	114	65	351	877.5	1097	274	46	2	0	0	1	0.0
Catabria	46	8	12	66	165	206	52	9	0	0	0	0	0.0
Castilla la Mancha	12914	2359	2536	17809	44522.5	55653	13913	2319	116	19	19	29	2.4
Castilla y León	19890	2396	1288	23574	58935	73669	18417	3070	153	26	26	38	3.2
Cataluña	3600	4259	605	8464	21160	26450	6613	1102	55	9	9	14	1.1
Extremadura	2957	1327	169	4453	11132.5	13916	3479	580	29	5	5	7	0.6
Galicia	2224	821	211	3256	8140	10175	2544	424	21	4	4	5	0.4
La Rioja	1450	2616	998	5064	12660	15825	3956	659	33	5	5	8	0.7
Madrid	722	67	38	827	2067.5	2584	646	108	5	1	1	1	0.1
Murcia	668	774	63	1505	3762.5	4703	1176	196	10	2	2	2	0.2
Navarra	1543	919	185	2647	6617.5	8272	2068	345	17	3	3	4	0.4
Pais Vasco	388	476	64	928	2320	2900	725	121	6	1	1	2	0.1
Valencia	2616	4765	94	7475	18687.5	23359	5840	973	49	8	8	12	1.0
Spain	**76287**	**32392**	**7374**	**116053**	**290132.5**	**362666**	**90666**	**15111**	**756**	**126**	**126**	**189**	**15.7**

A detailed analysis of the previous data indicates an heterogeneous and very different needs in terms of inspection workshops among the 17 regions. Values range from 32 inspection workshops in Andalucía to 0 in some other regions as Asturias, Canary Island or Baleares Island. This fact should be considered by the responsible in order to arrange the most adequate, productive and efficient inspection program in Spain. Based on the mandatory mutual recognition among the inspection workshops, may be in some areas should be considered the possibility for agreements between neighbor communities in order to save investment, increasing efficiency of the process, due to the fact of the very low number of sprayers.

Inspector's training: key point to guarantee the success

According the Spanish law to become director or technician of a inspection workshop an official certificate will be mandatory. This certificate (renewable every 5 years) will be acquired after the attendance to mandatory training courses delivered by official institutions. But, who will in charge of training and what should be the characteristics of the mandatory course? Te first part of the question is widely answered also by the law, which stated that universities (agricultural engineering departments), official training centers, research and development institutes, and whatever other official institution will be considered as a candidate for training responsible. This official scenario allows to local authorities to design the training responsible, with a great variety of expertise, background and facilities.

In order to harmonize as much as possible the training procedure, several Spanish universities have arrange a coordinate activity with the purpose to present at local authorities an homogeneous and even training program, including similar contents distribution, facilities and expertise, trying to avoid unappreciated differences among the regions. Fig. 4 shows the map including the involved universities.

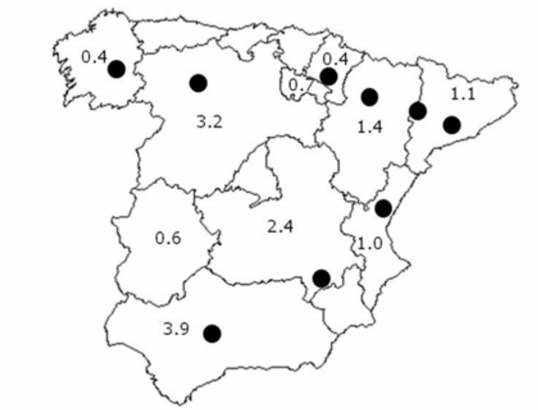


Fig. 4. Expected numbers of training courses and placement of involved universities with a harmonized training procedure.

Regarding the training course characteristics, the Spanish law publish (Annex IV) the mandatory requirements in terms of contents, length and distribution time between theory and practices activities. A forty hours course (one whole week) has been designed with a distribution of 60% theoretical activities and 40% practices. At the end of the course a mandatory exam has been established on which at least one whole inspection procedure has been included from the practical point of view. The attendance to the course is mandatory for all the intended inspectors and some requirements in terms of background (specific university degree or professional training degree) is required. Contents related with agriculture, machinery management and design are mandatory to become inspector.

Training and education: basis for a success

Based on a wide previous experience on all over the regions, training and a good information and educational procedure for the users has become a key point to guarantee the success of the inspection procedure (Gil, 2001; Gil and Gracia, 2004; Gil, 2007). This fact can be guaranteed by following two main lines: a) an adequate and high level training scheme of the inspectors and b) implementing as a mandatory some informative/training activity during the inspection process itself, promoting the participation of the users and increasing their knowledge about what/why and how different measures, requirements or evaluations are done during the process.

For this purpose, some agreements were achieved among the local responsible of the official inspection procedure in order to improve the user's knowledge during the process:

- Results of visual inspection must be explained /commented with the owner during the procdure itself.
- Results of different measurements (nozzle flow rate, pressure gauge, horizontal distribution…) must be explained (time consuming estimated 5-10 min) immediately after the measurement process.

Another interesting action to remark as official action implemented in Spain in order to increase the knowledge and education level of the users has been the publication of the manual of inspection of sprayers in use.

Fig. 5. Manual for inspection of sprayers in use. Available at www.uma.deab.upc.edu and www.magrama.es.

This tool is mainly focused and dedicated to facilitate the comprehension of the whole procedure for the future inspectors and inspection's workshop responsible. The manual (Fig. 5) has been developed by Polytechnic University of Catalonia, University of Lleida and Agricultural Machinery Center of Generalitat de Catalunya, and includes detailed explanation (with graphical and pictures support) of every single action to be developed during the inspection procedure. According the published on the Spanish law, the official manual of inspections is available on the official website of the Spanish Ministry of Agriculture.

Conclusions and remarks

After the long period and difficulties observed in Spain during the official procedure for the establishment of the Spanish law, some aspects or remarks must be considered:

- The establishment of an official inspection procedure at 17 different regions at a time is an im portant challenge
- Accurate information about number and distribution of PAE results key for an adequate organi zation
- Inspector's training must be managed as a "capital point" for guarantee the success of the whole process
- Recent modification on official procedure of inspections (EN 13790 substituted by ISO 16122) will increase the need of training
- MS who are in the process to establish mandatory inspection procedure should take advantage of experience of other MS already experienced

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How to implement a mandatory inspection in accordance with European directives: The example of certified workshops

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Introduction

Progressively, the European Commission has established a complete set of rules (Directives) and enlarged the field of those regulations. So, since many years, each national regulations have to take in account the European Directives when provided new rules in its own country.
So, during the implementation of a mandatory inspection of sprayers in France, it was absolutely necessary to fulfil the main principle of the free circulation of bodies and goods.
In this way, when preparing our regulations, three main Directives had to be integrated in the regulations concerning the mandatory inspection of sprayer.

- Even if the French regulation started in 2009, the Framework Directive for a sustainable use of pesticide (2009-128) was still in preparation, and the main goals were still known.
- The Services Directive (2006-123) should simplify all procedures used in creating and establishing a service activity (like sprayer inspections)
- The recognition of professional qualification Directive (2005-36), demands a simplification of procedure of recognition in regulatory activities.

In this context, the French rules were written in order to facilitate the implementation of sprayer inspection's workshops, establish in France or in other European countries. Some details will be given here, explaining how workshops are agreed for this activity.

The French sprayer inspection; a long story!

In 2000, a first attempt to put into force a mandatory inspection of sprayer was started. Unfortunately, the law prepared in 2002 has not been published (changes in the ministerial priorities). So, the discussions re-started in 2005 for a publication of the law in 2006. The specific decrees and ministerial rules were finally published in 2008, in order to start the mandatory inspection in 2009.
During this period, a European tour has been made, in order to collect some very useful information coming from states which have implemented such mandatory inspections. Especially, Belgium, Germany and the Netherlands were asked for their experience (several years of inspection). The people involved in sprayer inspection gave us their feeling and feed-back about their organisation and procedures. These discussions permit to make ours the best points and adapt or modify the worst ones in order to improve the first basis of the French rules.
Moreover, it was important for our point of view to take in account all the voluntary operations developed all around in France. Many meetings with professional organizations (farmers, manufacturers …) were organised in order to present and discuss all the projects. Those discussions allowed the optimization of the regulations and a quick start of inspections.
Finally, and according the 2009-128 Directive, the organization is based on three main sectors:
Teaching : the inspector are specially teach in specific teaching centres. Those centres have been agreed by the State. In order to obtain this agreement, teachers have to receive a complete set of information's and teaching materials. They are also submitting to audits, made once two or three years.
Inspecting : the workshop have to be specially agreed for this job.
Controlling / organizing: a specific organization (GIP Pulves) has been created in order to survey and organize the scheme. This structure has to answer technical and administrative questions, collect all data's coming from the inspections. It seems to be the main originality in our organisation: a complete centralized organivation, very light (2 persons) at totally dedicated to the sprayer inspection. It is directly connected to the French ministry of Agriculture. It gives an accurate knowledge on this subject, which permit a high reactivity and quick answers and upgrades for the inspection's methodologies and practices.

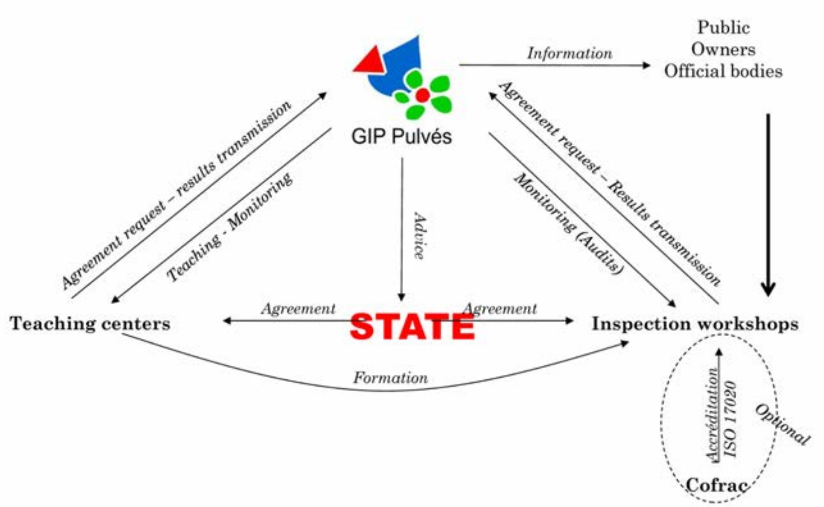

Fig 1. Global organisation of mandatory inspection of sprayer.

Three directives may concern the agreement of workshop

When preparing the agreement's procedure for workshop, we had to mind to European Directives (already published or under preparation)

The framework Directive for a sustainable use of pesticide

The Directive says that "the member states should define the bodies which have on charge to realize the inspection, and has to communicate to the european commission the list of the certified bodies."

From our point of view, it means that the workshop have to receive an agreement. It means that the State has to install a recognition system, to guarantee the competence and an adapted organisation.

The agreement system in France is based on two principles:

- Person's education: the inspectors have to follow a teaching cycle, divided in two sessions. The first step (4 days) is based on general information concerning the regulation, the sprayers, the safety of operators, and the main principles of the inspection. It is evaluated with a multiple choice questioner. Only people receiving at least 20 good answers from 30 questions can reach the second level. This one concerns only the inspection protocol (2 days) and at the end of this stage, each participant shall realise a complete inspection, in 2 hours. If not, he will not be validated for inspecting sprayers.
- Quality system. Two possibilities are available. The first one is based on international standards (ISO 17020) evaluated by an independent association (Cofrac). It means accreditation for inspection activities.
- The second one is based on external audits by the GIP Pulves. Each 15 month, the workshops are audited, during a complete day. The inspector has to realise a complete inspection, he has to provide to the auditor all documents concerning the metrological control of the instrumentation (procedure, certificates…), and he has to explain the global organisation, administrative functioning (storage of documents, communications, customer's management…).

Professional recognition

As shown previously, the agreement of workshop is necessary to insured a high level of competence. One main condition is the education system. A specific Directive (2005-36) concerning the recognition of professional qualification has been transposed in the French regulation. So, inspectors who have an official recognition in their own countries (it means official certificates or licence) can work for any certified workshop in France.

It means that we consider that any inspector working in the sprayer inspection in Europe is efficient and do not need any additional teaching courses.

However, inspector have to declare its activity to the GIP Pulves (like any inspector), and, in order to be allowed to work, he will have to present its local certificate. If needs be, during the first audit, some additional recommendations and information can be given for a complete adaptation to our national rules.

Services Directive

In order to facilitate the establishment of services activities in Europe, the 2006-123 Directive ask to simplify the procedures to create or implement the same activity all around the European Economic Space.

In the French regulation, we consider any certified workshop in the same way. For European workshops, already agreed in one country, a preliminary declaration has to be addressed to the GIP Pulves. After reception of this request, this workshop will be considered like anyone else: the audit process by accreditation office or the GIP Pulves structure or its national supervising organisation.

The workshop will preliminary have to provide its local agreement (naturally, the validity period will be checked).

After this administrative registration, the workshop just has to follow the same requirements than all other workshops: methodology of inspection, organisation, metrological specifications for the equipment, data transmission in the national database, and payment of fees for each inspection. The workshop will be included in the list of authorized bodies, regularly updated and published.

How to comply with the main exigencies of the 2009-128 framework directive?

Without coming into too many details, the framework Directive also stipulates:

A.That the sprayer inspection is mandatory, with regular intervals not exceeding 5 years.

This item is quite easy to transpose, but, it should be taken into account that all kind of sprayers are concerned by this. In the French regulations, in the law (highest level of rules) it is said that all kind of machines applying pesticides are submitted to such an inspection, with a five year interval. In more detailed rules, we define the different categories of machines and the methodology of inspection dedicated to each one.

B. That the member state shall recognise the certificates delivered in the other countries.

It is mentioned in the 6th paragraph.

In France, the general decree, insure this recognition, but three conditions should be respected:

- The inspection of the sprayer had to be done by a certified workshop
- The certificate establish in the original country is valid. Because of the different inspection intervals, the limit of validity taken in account is the one attributed by the country where the inspection has been done (no prolongation, no limitation).
- The sprayer has to be declared to the GIP Pulves when arriving in France; it allows providing some advice to the owner about the date of the following inspection.

For farmers establish in a neighboured country and cultivating fields in France, there is no need to do anything; they just have to follow their local requirements.

C. That the inspection procedure shall follow some essential requirements edited in the directive.

In order to provide the list of inspection points, the French rules are based on: the standard available in 2008 (NF EN 13790 series), the procedure used for voluntary inspections (some defaults not included in the standard were still inspected) and the feedback from other countries. It was really important to collect the experience of inspectors, especially not to define unrealistic inspection's point. Moreover, the methodology of inspection should be strictly defined without using general wording, which can be understood differently. The list of inspection defects is edited in ministerial rules for different categories of sprayers. Actually, for field crop sprayers 63 inspections points are relevant, corresponding to 179 defects.

In the future, some additional annex will be edited, for a full adaptation of the ISO 16122 standards (in preparation) and integration of some other type of sprayers.

Three years' experience after implementing this new regulation

France is the last country which have implement such a regulation since the publication of the three directives mentioned earlier. The main experience is that, building such a regulation needs time and cannot be put into force in few months. It is necessary to discuss with all the people involved in the crop protection: farmers association, manufacturers, equipment distributors… The rules should preferably be explain and communicate before their entry into force; it allows a quicker start and a quite

well acceptance of the new obligations. Particularly, if voluntary inspections have been implemented in the past, the mandatory inspections should preferably be as close as possible of the older scheme in terms of protocols and organisation. In our case, more than 75% of the actual inspectors were involved in the voluntary scheme. They were efficient with only a short teaching (2 days used to upgrade their knowledge for the new protocol).
So, less than two after the publication of the rules, around 20 workshops were already agreed for the mandatory inspections. In 2012, three years after starting, 5 teaching centres are agreed and more than 140 workshops. This level has been reached in 18 months. Today, the total French territory is covered (even in the French West Indies –FWI- islands !). This quick installation is due to a good communication two years before the entry in force of the regulation and the voluntary scheme installed and used for implementing workshops.
Another important point is the flexibility in the official text. From our point of view, it is difficult to prepare some definitive text and methods: the great variety of sprayers (more than 100 manufacturers are present in France), we sometimes have to adapt the methods to new situations. If everything should be strictly defined in the official texts (agreement procedures, teaching content, sprayer's defects) some other should be preferably written in a lighter way than official text (it takes time to approve and publish new rules in the official gazette).
The GIP Pulves edit a technical guide, where all main principles are remind, but additional information's are presented. For example, if the ministerial rules defined the defects (ie boom bending limits) the methods used for measuring are given in this guide. It gives also technical information about classification of sprayers and nozzles.
Moreover, the metrological specifications are given in this guide, with a complete scheme and procedures for testing the accuracy of the equipment. In order to integrate the progress due to innovation and new equipment's, we did not establish a closed-list of available equipment's but only metrological limits are provided. Each one can use (or build) its own equipment, which can be accepted if the minimal accuracy is reached.

A national database for collecting all the information from inspections

In addition to this organisation, the official bodies decided to implement a specific database, collecting all data's coming from the inspections. In this way, some interesting information can be registered: Characteristics of the sprayers (manufacturer, model, width, regulation system, tank capacity, year of building…), the localisation, and the defects encountered for each inspection. In order to be able to follow each sprayer, a specific registration has been implemented: a sticker with a unique number is fixed on the machine during its first inspection. It will be possible to determine how the sprayers make old, and the main points to take care when years go on.

	(M ha)
Arable crops	12,9
Grassland	14,6
Orchard	0,4
Vineyards	0,8
Forestry	23,3

Fig. 2. Distribution of the French territory.

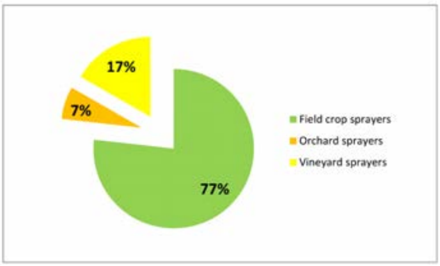

Fig. 3. Distribution of type of sprayer

Even if the orchards and vineyards represents around ten times less areas than field crops, the bush and tree sprayers represent more or less one quarter of the machines. Effectively, the characteristics of such machines make them relevant only for 10 to 30 ha max, per sprayer. Moreover, in some particular regions, machines can be used for very small areas (eg in Champagne, the average surface of vine per farm is about 2 ha).

Examples of technical description given by the data base:
- 40% of field crop sprayers are equipped with a travelling speed regulation system but only 8% of the vineyard sprayers;
- Field crop sprayers are divided in two mains classes: those used in mixed farms (livestock + crop) with booms comprised between 12 and 15m and those used in large farms (arable crops only) with booms between 24 and 28 m. Each category represents more or less one third (See Fig 4).
- For vineyard sprayers, more than 85% are pneumatic sprayers and 10% air assisted.

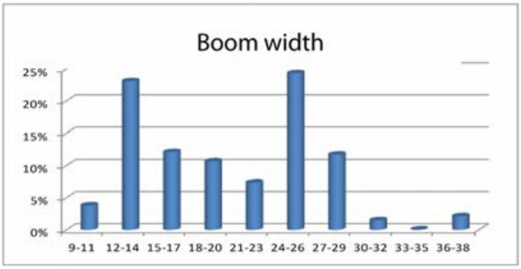

Fig. 4. Distribution of the boom width.

Those data's can be precisely established, with geographical analysis, and / or crossed request (age vs boom width, tank content vs type of production …). This new knowledge about the characteristics of the sprayer will be used by technicians in order to prepare some well adapted teaching and / or information for farmers.

Examples of inspection details given by the data base:

- The geographical distribution is heterogeneous all-round the French territory (see fig 5), due to different farming systems
- The average number of defects per inspection is about 5; logically, it increased with the age of the machine but not with high rate. The oldest machines (more than 25 years) are generally well kept by owners and generally pass the inspection's test without being rejected!
- The two main defects concern the boom deformation and the accuracy of the manometer. It is encountered in 50% of sprayers (minor + major defects)
- Around 20 to 25% need to be repaired before receiving the sticker.

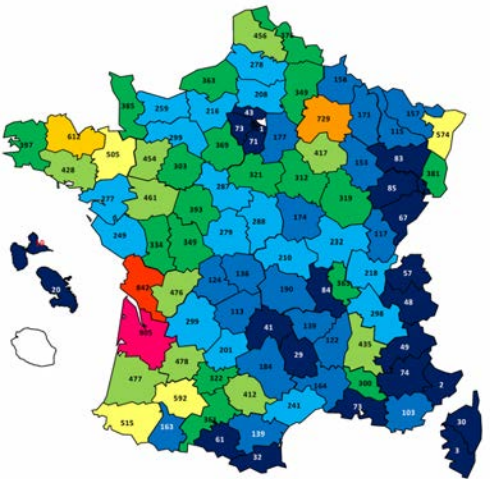

Fig. 5. Distribution of inspection in France.

Conclusion

Starting the implementation of mandatory inspections of sprayer seems to be quite easy considering the poor number of sprayers and owners concerned by such regulations. However, from the administrative point of view is exactly the same whatever is the scale of the project. Teaching centres, inspections workshops and organisational structure have to be put into force in a few time, and in accordance with European rules. When the scale of the subject is not very large, it may be useful to minimize the number of partners and rules. In France, the centralized organisation, with a light and specific structure at the head is a real chance for harmonising the methods and insures a quick broadcasting of information and data's. All the agreements are given at the national level and everyone can move from one part of the territory to another one without any difficulties. On the other hand, the completion of a national database gives some useful information about the state of the sprayers, their geographical distribution and will be used for well adapted advertising.

One difficulty encountered is the communication to owners of sprayers (not only farmers are concern but every kind of owner). Using professional newspapers and/or professional organisations is necessary, but seems not to be enough. It appears to be difficult to inform the owners about the new regulations and usefulness of such inspections. If the main goal of the inspections is to minimize environmental and operator's contamination, inspections shall also be presented in such a way that owners will find some direct benefits to that; for example, less consumption of pesticides (eg accuracy of the sensors), better distribution in the canopy (eg nozzle spacing) …

Actually, in France, the main problem still is the fulfilment of this regulation. We consider that only 40% of farmers have submitted their sprayer to this inspection. Many reasons may explain such a lack: financial difficulties (specific vineyards or fruit productions), climate events (dryness during 2011's spring), fear about the poor condition of their machines (which will not satisfy the minimal request during inspection)…?

It is now absolutely necessary to insure that this regulation is respected by each owner. If around 1% of the farms are visited by official bodies every year, it appears not to be enough in order to complete a satisfying number of inspections. We now have to mind to other tools in order to finalize the introduction of this regulation and make it successful.

Inspection of new sprayers

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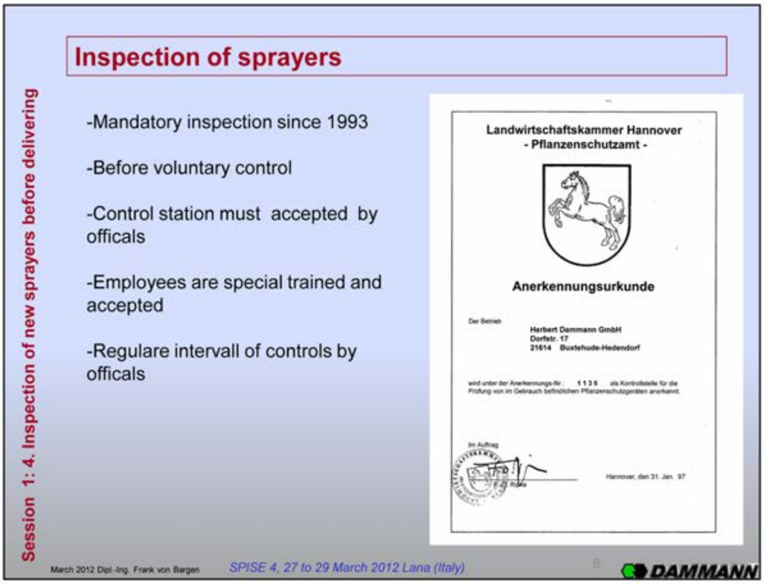
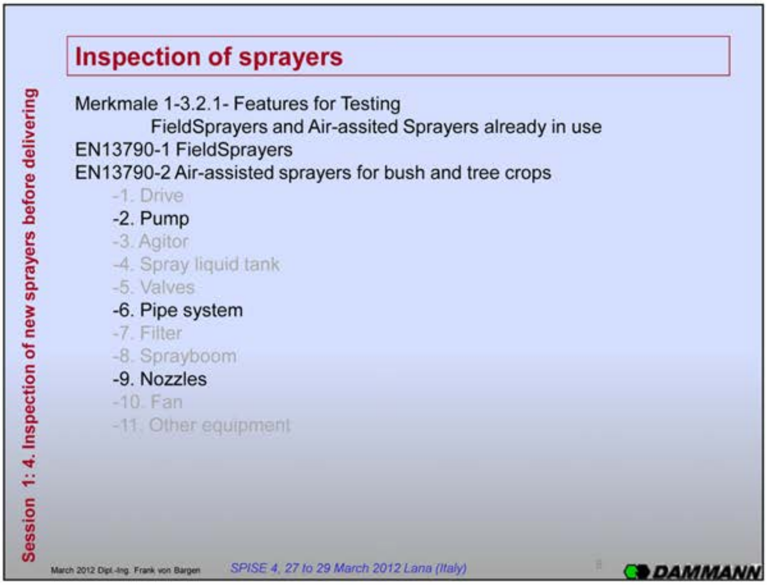
How to deal with brand new PAE have been already discussed at the last SPISE workshops at Straelen 2007 and Brno 2009 with the following result:
"Brand new sprayers have to be inspected before selling or they have to be manufactured in such a way to fulfill the EN 13790 standard. Inspection of new sprayers may be of reduced extent compared to sprayers in use."
The advantages of inspections for brand new equipment before it leaves the factory instead of waiting until it has been used for five years is seen by several manufacturers of PAE. Also in the CEMA's and furthermore the DG SANCO's opinion, this approach is practical and is therefore supported.
Manufacturers know for sure that not wear and tear in this case is the reason of any inspection. But defects of the production as leakages of screw connections can be detected easily. Over that all kind of residuals, for instance cuttings arising during the drilling procedures can lead to blockages of filters and nozzles. Such defects can be eliminated very early and any discontent of customers can be avoided.
To fulfill the German requirements for testing brand new equipment only the features pertaining to pump, pipe system and nozzles shall be applied.
All in one purchaser willingly make use of this service of the manufacturer/dealer of PAE.

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Inspection of sprayers
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EN13790-1 FieldSprayers
EN13790-2 Air-assisted sprayers for bush and tree crops
-1. Drive
-2. Pump
-3. Agitor
-4. Spray liquid tank
-5. Valves
-6. Pipe system
-7. Filter
-8. Sprayboom
-9. Nozzles
-10. Fan
-11. Other equipment
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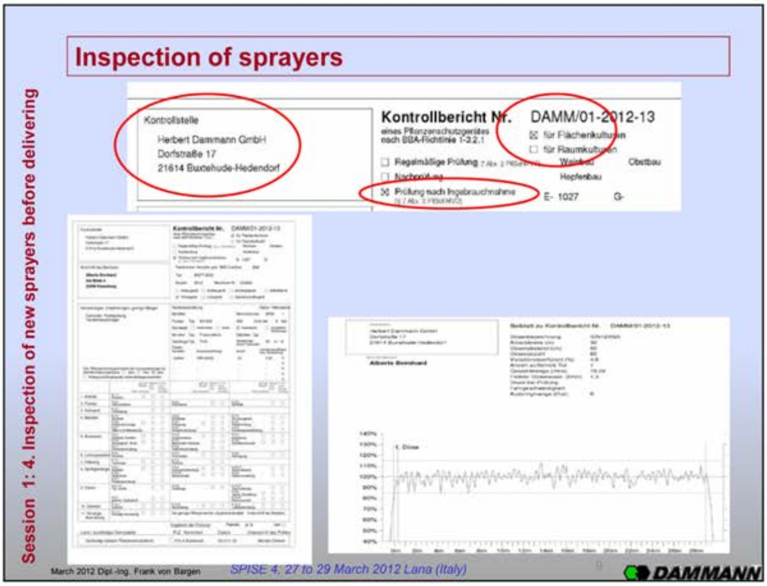
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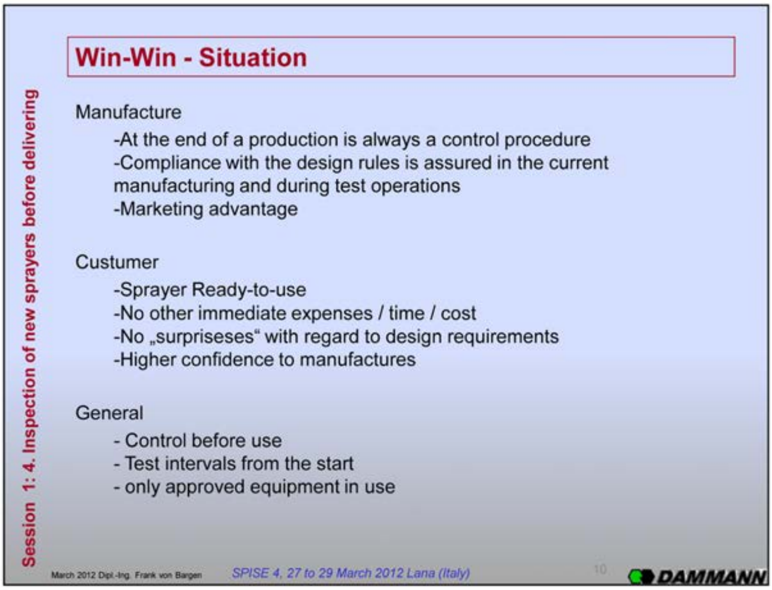
Session 1: 4. Inspection of new sprayers before delivering
Win-Win - Situation
Manufacture
-At the end of a production is always a control procedure
-Compliance with the design rules is assured in the current manufacturing and during test operations
-Marketing advantage
Custumer
-Sprayer Ready-to-use
-No other immediate expenses / time / cost
-No „surpriseses“ with regard to design requirements
-Higher confidence to manufactures
General
- Control before use
- Test intervals from the start
- only approved equipment in use
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Session 2 : Member States may apply different timetables and inspection intervals with exceptions following a risk assessment and exempt handheld pesticide application equipment or knapsack sprayers

Introduction paper

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Summary
Article 8/3 of the European Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use of pesticides allows the Member States to derogate from the mandatory inspection at regular intervals for certain types of pesticide application equipment (PAE).
The derogation is based on a risk assessment for human health and environment and an assessment of scale of use. The FWD does not give any clear instruction and/or indication on these assessments. Nevertheless the MS will have to carry out these ones if they want to introduce derogation and without having a clear protocol, an uneven situation may occur within the MS. Risk assessments should be clarified.
The purpose of this paper is to introduce the notion of risk assessment based on a literature review and to clarify this assessment in regard with the Directive 2009/128/EC.
Key words: sprayer inspection, derogation, risk assessment

Introduction
Article 8/1 and 8/2 establish the main scope of the mandatory inspection in EU. This scope covers all types of Pesticides Application Equipment (PAE). Considering the MS particularities and the unavailability of standards or valuable protocols, the Article 8/3, by introduction derogation possibilities, makes lighter the implementation of the FWD.
Article 8/3 of European Directive 2009/128/EC on the sustainable use of pesticides allows the Member States to derogate from the mandatory inspection at regular intervals of certain types of pesticides application equipment (PAE) based on a risk assessment for human health and environment and an assessment of scale of use.
During the SPISE III (2009), the analysis of article 8/3 of the Directive allowed us to define a classification scheme of the PAE according to their potential of derogation from the mandatory inspection and to conclude on the necessity to go deeper into the risk assessment process. Three years later, we have to notice that we didn't progress so much in that subject. The major problem is that the COM didn't give clear indication/instruction on this risk assessment and that the priority in many Member States is at least to start the inspection of boom and orchard sprayers as soon as possible.
This paper makes the points on the risk assessment and its implication into the sprayer inspection and the fulfilling of the requirement of the Directive 2009/128/EC

Definition of risk related to a hazard and the risk assessment
Following the ISO 12100, the risk assessment is an overall process comprising a risk analysis and a risk evaluation. Although, this definition remains relatively hazy and asks for more explanation, it is interesting to note that the risk assessment isn't limited to an estimation of the risk but includes other concepts as the risk evaluation and the risk analysis.
Before to go further in the analysis of the risk assessment, we have to remind the definition of the risk itself. The risk is the combination of the probability of occurrence of harm and the severity of that harm (ISO 12100).

Fig. 1. Definition of the risk.

The risk associated with a particular hazardous situation depends on the severity of the harm resulting from the hazard and the probability of occurrence of that harm.
Coming back to the Directive 2009/128/EC, we have to understand the term "harm" in the broad sense including "harm" for the Human Health and the Environment. The risk related to the use of a non-inspected PAE will be estimated for the Human Health and the Environment.
The severity of the harm can be estimated quite easily by taking into account the severity and the extent of the damage. The probability of occurrence of harm is a function of three notions:

- The exposure of the studied target to the hazard: the probability of the occurrence of "harm" could be influenced by factors as the need for access to the hazard zone, time spent in the hazard zone is also an important factor, frequency of access...
- The occurrence of the hazardous event: statistical data and accident history would be helpful to estimate the occurrence of a hazardous event.
- Possibility of avoiding or limiting harm: with this notion we are already much more in the action and the minimizing of the risk. Factors as training of the operator or supplying of information, indication, warning signs...could be taken into account.

Risk assessment as an overall process

Risk assessment is 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 12100).
To implement risk assessment the designer shall take the following actions (see Fig. 2):
a) Determine the limits of the machinery (PAE): allows to precise the limits where risk assessment will be apply and to avoid any confusion of scope (e.g. : the risk assessment of the use of a non-inspected PAE is not the risk assessment of the pesticides, or of the user's skill...).

b) Identify of the hazards within the defined limits of the machinery: this essential step consists into the systematic identification of reasonably foreseeable hazards, hazardous situations and/or hazardous events within the defined limits of the machinery.

c) Estimate the risk for each identified hazard and hazardous situation, as define before (see Fig. 1), combining the severity of the harm related to the hazard and its probability of occurrence.

These three first steps constitute the risk analysis which is the first phase of the risk assessment.

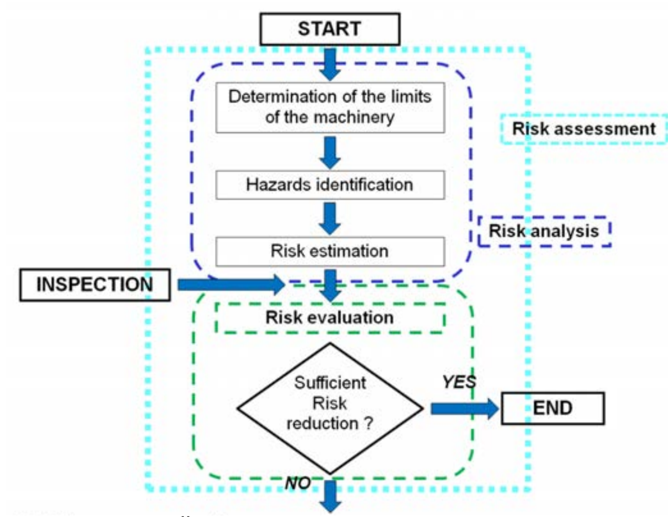

Fig. 2. Risk assessment as an overall process.

After the risk analysis, the overall process of the risk assessment needs two other steps which are determining and indissociable: an action aiming at reducing the risk and the risk evaluation.
The action, in our case, is simply the inspection following the standardized protocol. The risk evaluation consists into a judgment, on the basis of the risk analysis, of whether the risk reduction objectives have been achieved (ISO 12100). A positive risk reduction means that the action, the inspection in our case, is sufficient to reduce the risk under an acceptable and reasonable level.
On the other hand, a negative risk reduction means that the undergone action is useless and cannot reduce the risk. In that case, another more appropriate solution would be developed and applied. Then the risk assessment is followed by a risk reduction process which follows its own protocol and procedure. Iteration of this process (risk assessment + risk reduction process) can be necessary to eliminate hazards as far as practicable and to adequately reduce risks by the implementation of adequate measures.

The described process can be illustrated by the following examples related to the sprayer inspection:
a) **Large leakages on orchard sprayers**: leakage is considered in the limits of the machinery. The hazard for the Environment could be the pollution of the surface water (aquatic organism). In Belgium, (Declercq J. & al, 2012) leakages on orchard sprayers in use considered as large (> 30 ml/min) have an occurrence of 9 % of the inspected machines. The risk is then quite high resulting of the combination of a non inconsiderable severity of "harm" for the aquatic organisms (depending on the pesticides, just few droplets of mixture could destroyed these organisms) and a high probability of occurrence considering the percentage of sprayers presenting large leakages. During the inspection, these leakages are determined and afterwards repaired. The risk to pollute the surface water is obviously reduced. We may conclude that the inspection is useful to reduce the risk for the Environment related to the large leakages on orchard sprayers in use.

b) **Overdosage of handheld spray lance/gun**: overdosage is considered in the limits of the machinery. The hazard for the Human Health could be an exceeding of the MRL. These sprayer types are quite common in glasshouses for fresh vegetables (tomato, pepper, salad, strawberry…) and ornamental crops production. One estimate in Flanders shows that more than 2800 glasshouses (70.5 % of total) are sprayed by using a gun (Goossens E. and Sonck., 2006). Moreover a great quantity of active ingredient (a.i.) is used in glasshouses. Following national statistics established in 1997, the growers used on average 27 kg a.i./ha for strawberry, 45 kg a.i./ha for flowers, from 20 to 260 kg a.i./ha for pot plant… which could cause a potentially high risk of pesticides residue on food plants. On the other hand, trials (Langenakens J. & al, 2002) showed that the applicator using a spray lance/gun has a greater influence on the spray quality than the equipment itself. Therefore the inspection of this type of sprayer cannot reduce the risk related to excessive residue on plant. Training the user seems to be the best tools to reduce that risk.

Discussion

The risk assessment is an overall process and should be associated to a risk reduction process in order to reduce adequately the risk related to the considered hazard or hazard situation. Usually for that purpose, experts and designers develop several combined solutions.

Following the Directive 2009/128/EC, the first solution to reduce all risks related to the sprayers in use is the inspection. Secondly, based on a risk assessment, Member States may derogate to the inspection of certain type of PAE and apply other timetable and inspection intervals or may exempt from the inspection handheld pesticide application equipment or knapsack sprayers providing the operator is trained.

To base the derogation on a risk assessment is a good process. That will allow determining the limits of the inspection as a solution to reduce the risks related to the sprayers in use. But, to give as replacement solution the postponement of the inspection or/and the lengthening of the inspection interval is a non-sense, because the risks related to the sprayers in use by inspection normally only are very limited reduced. Additionally, an inspection of a knapsack sprayer in practical use is estimated to cost almost the price of a new sprayer. However, training, self check and calibration are more important tools in order to minimize the level of risk (safety, environment and overdosing)..

The two examples of risk assessment given previously show that the work waiting the Member States is huge. The process would be applied for the PAE under derogation taken into consideration all hazard situations for Human Health and Environment. Sub-targets would be also taken into consideration (e.g. : under Human Health, we could consider the operator, the inspector and the citizen). All these factors will multiply the number of risk assessment that will be realized.

The risk assessment process needs to be fed by statistics, data and expert's views. To find these inputs and to ensure their representativeness is also a great challenge. Fuzzy expert system could help and would be explored. It allows objectivizing expert's views when a lack of raw data is present. This system has already used successfully to define indicator of pesticide environmental impact (Roussel & al, Hayo & al).

Conclusion

Following the ISO 12100, the risk assessment is an overall process comprising a risk analysis and a risk evaluation. The risk analysis combines the specification of the limits of the machine, the hazard identification and the risk estimation. The risk evaluation follows a certain action (e.g.: the inspection) and consists into a judgment, on the basis of the risk analysis, of whether the risk reduction objectives have been achieved.

Article 8/3 of European Directive 2009/128/EC on the sustainable use of pesticides allows the Member States to derogate from the mandatory inspection at regular intervals of certain types of pesticides application equipment (PAE) based on a risk assessment for human health and environment and an assessment of scale of use. Unfortunately, the COM didn't give clear indication/instruction on this risk assessment. Moreover, analyzing the article 8/3 of the Directive, it seems that the COM limited the risk assessment to only the risk evaluation which is the first part of the overall process.

Regarding the deadlines of the Directive 2009/128/EC implementation by the Member States (2016), there is a real need to go forward in the subject of the derogation and the related risk assessment. A common process would be developed while at the end the result would be different from Member State to another considering the local use.

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The trials on the influence of knapsack sprayer technical condition on operator exposure as an input to the risk assessment for human health

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Summary

Operator exposure to spray applied with knapsack sprayers was measured in the open field during the spraying of the low, medium and high plants (strawberries, young apple orchard and bearing fruits one). The samples were attached to the protective clothes in 13 locations. The BSF fluorescent tracer was added to the spray. The operator exposure was expressed as the part of the dose applied (ppm). The data on operator exposure was used to predict the risk for operator. The risk for humans was done by computer modeling according to German BBA model, taking into account field data for different sprayer technical conditions and 15 different pesticides. The most important influence of the sprayer technical condition on the operator exposition and the human health risk was observed for high crops.

Key word: operator exposure, knapsack sprayer, open field, fluorescent tracer, risk assessment

Introduction

Directive 128/2009/EU on sustainable use of pesticides states that 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 (art. 8.1). 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.

Spraying with pesticides may become the potential source of the contamination of the operator and of the surrounding areas. The proper functionality of knapsack sprayers depends on its technical condition and may influence the operator exposure. Therefore the knowledge on the influence of the most common sprayer damages on operator exposure may help in deciding on "to inspect" or "not to inspect" such spraying equipment. The risk assessment for human health may be done by in silico modeling (computer modeling). At least two models are suitable for that purpose. The aim of the analysis is to calculate the operator per day exposure expressed in mg/kg of body weight. Then the operator exposure may be compared to the maximum amount of the active ingredient on which the operator may be exposed AOEL (Accepted Operator Exposure Level).

One of the first measurements of operator exposure to plant protection products (PPP) were done by Durham and Wolfe (1962). The measurements were carried out in professional and amateur production (Chester, 1993; Gilbert, 1995). The operator exposure measurements are included in the PPP registration/legalisation procedure. Despite of that only wery few data on that topic are to be found in the scientiffic literature. The review of early tehniques of operator exposure measurements were published by Wolfe (1976).

Nowadays many measurements of operator exposure are done with fluorescent tracers collected on the whole protective overal (Sutherland et al., 1990; Bjugstad and Hermansen, 2009) or on the samples placed on its surface (Bjugstad and Torgrimsen, 1996; Bjugstad and Hermansen, 2009). In some cases the visualisation of fluorecsent tracer in UV light is used or methodes of bio-monitoring basing on quantitative analisis of metabolites of non-toxic pesticides in operator urine (Krieger and Dinoff, 2000). In EU Member States it is accepted for risk assessment of exact PPP applied in exact way to predict the exposure basing on measurements data for field trials for other PPP applied in similar way (Ludwicki et al., 2003).

When the operator exposure is measured in industrial context, the mass units per time units are used (e.g. miligrams per hour). In some cases such units were used in agricultural context (Batel, 1984). However, because of different efficiency of plant protection equipment (different spray volumes sprayed in time unit) such units need to take into consideration the time of application. Therefore the best way of expression of operator dermal exposure during spraying is using of mass units per operator surface

units and express it as a percentage of the dose applied (Bjugstad and Torgrimsen, 1996). Such measure enables the comparison of exposure for operators applying different doses of products with different equipment in different crops. Such units were used by Abbot at al. (1987) and Bjugstad and Torgrimsen (1996).
The aim of the trials was the assesment of the influence of knapsack sprayer technical condition on the sprayer operator exposure during application in three different types of crops. Then the exposure values were used during in sillico modeling with BBA model to predict the possible risk for humans for the application of PPP by means of the knapsack sprayers in different technical conditions.

Material and methods

The field trials were carried out in July 2010 in the experimental orchard of Research Institute of Horticulture, Skierniewice. The efficient undamaged knapsack sprayer and the sprayer with damaged nozzle and with damaged gun valve were used. The measurements were done in low crop (strawberries), medium loose one (young orchard) and in high dense one (bearing fruits orchard). The fluorescent tracer was added to the spray and the samples were attached to the operator overal. The operator exposure was expressed in ppm (parts per million) of the dose applied.
The risk for humans was done by computer modeling (in sillico modeling according to German BBA model) taking into account typical spraying scenarios, different sprayer technical conditions and 15 different pesticides. The pesticides of different NOAEL (No observed adverse effect level) values dependent on chosen PPP's toxicity were used during in sillico modeling. Then the operator exposure achieved in the model was compared to the AOEL (Acceptable Operator Exposure Level) values to find out if the combination of the PPP and the sprayer technical condition makes a risk for human health or not.

Experimental factors – technical condition of the sprayer
Three sprayer conditions were examined:
- efficient – undamaged knapsack sprayer,
- sprayer with gun valve damaged (valve kept opened during the whole test),
- sprayer with damaged nozzle (outlet scratched with sharp tool giving uneven spray stream).

Experimental factors – crop
The measurements were done during spraying of three kinds of crops:
- low crop (strawberries, row spacing 1.0 m),
  - two neighboring rows were sprayed – plot length 40 m
- medium-loose crop (1.8 m in height young orchard),
  - one row was sprayed – plot length 30 m
- high-dense crop (3.0 m in height bearing fruits orchard)
  - one row was sprayed – plot length 20 m.

Sprayers
Two 15 l knapsack sprayers were used for the trials:
- in low crop:
  - one Kwazar Neptune 15 sprayer, 1.2 m long lance (Kwazar Corporation Sp. z o.o., Poland)
  - one Solo 425 sprayer, 50 cm long lance (SOLO Kleinmotoren GmbH, Germany)
- in medium and high crops two Kwazar Neptune 15 sprayers were used.

Each sprayer was equipped with one LU 120-04 Lechler nozzle witch nominal flow rate 1.55 l/min (at 3 bar) producing medium drops (VMD ca 240 µm).

Sprayer operators
The treatments were carried out by two operators (height of *ca* 175 cm): experienced (57 years old) and inexperienced one (27 years old). Operators wore DuPont™ Tyvek® overalls.

Spaying liquid
Operators sprayed out the water solution of 0.3% BSF fluorescent tracer (Brilliant Sulfoflavin, WALDECK-Gmbh & Co KG DIVISION CHROMA, Germany). The spray was prepared in the tank of the orchard sprayer, taking 600 g of BSF for 200 l of tap water. For each trial the solution of 5 or 10 liters of BSF was measured out of the tank.

Trials

The separate plots for each operator were set. The single trial constituted of spraying out of 5 then next trial with 10 liters of BSF solution. The plots length were crop depended (20÷40 m) (look at: *Experimental factors – crop)*. The time and the distance taken by each operator during each trial were measured. The manner of spraying was operator depended, no suggestion or instruction were given to the operators, except one indication: the need of spraying the whole height of the high crop trees. During the trials operators wore white DuPont™ Tyvek® overalls produced by DuPont™. On the overalls the measurement points were located according to BBA scheme (tab. 1). In each of the measurement points the Velcro strips (6 cm in length) were attached, on which the Technofil filter fiber samples (5 x 10 cm) were placed (Filtermatten TF-290, Technofil B.V). In each measurement point two samples were mounted giving two 13-samples sets on the overall. The samples were removed in two stages: one set - after spraying out of 5 liters of BSF solution and the other one - after spraying of subsequent 10 liters of solution.. The protective gloves were taken off together with each set of the samples. After each trial the Tank Mix solution was taken in the frame of the controlling procedure and for calibration of the laboratory equipment (Perkin Elmer LS 55). Every trial was repeated twice. In each crop 24 trials were carried out giving 72 trials in total.

Working parameters during trials

The time of single "shorter" trial (spraying out of 5 liters) ranged from *ca* 3 to ca 5 min (182÷298 sec), 6 to 11 min for "longer" (10 liters) trials (367÷650 sec) and the summarized time of "shorter" and "longer" trials (spraying out of 5 + 10 l of BSF solution) ranged from 10 to 15 min (559÷920 sec). The spray volumes per hectare resulting from trials were: 278÷658 l/ha in low crop (strowberries), 114÷219 l/ha in young orchard (medium crop) and 147÷368 l/ha in high crop (fruit bearing orchard).

Laboratory measurements, calculations and modeling

Samples and protective gloves taken off from the operators overalls were closed in the containers. In the laboratory the concentration of the tracer rinsed out from the samples and protective gloves was measured on PerkinElmer LS 55 spectrofluorometer. The rinsing solution was deionized water: 100 ml for Technofil samples an d 300 ml for protective gloves. All samples were shaken for 15 min on a special stand with shaking frequency of 162 Hz and amplitude of 4.0 cm. Then the total spray deposit (mass per location) for each location was calculated taking into account measured tracer concentration, samples area (50 cm^2) and rinsing liquid volume, as well as the body surface area for each location (tab. 1). Then the total operator exposure (basing on deposits in 15 locations) and the partial exposure (total exposure without amounts on lower legs and the gloves) were calculated. The measured values of operator exposure were too small to express it as a percentage of the dose applied, therefore the ppm measure (parts per million) was used for expression of the gathered exposure data.

Tab. 1. Samples location and body surphace based on BBA scheme.

Body Surface Area (cm^2)		Sample no
Location of samples	Area (cm^2)	
1 Chest (front)	3550	1
2 Back	3550	Mean for: 2, 3, 4
3 Shoulder right		
4 Shoulder left		
5 Upper arm right	1455	5
6 Upper arm left	1455	6
7 Forearm right	605	7
8 Forearm left	605	8
9 Thigh right	1910	9
10 Thigh left	1910	10
11 Lower leg right	1190	11
12 Lower leg left	1190	12
13 Head	1300	13
14, 15 Glove right, left		14, 15

Tab. 2. Pesticides used for *in sillico* modeling.

No	PPP name on the Polish market	Active ingredient (a.i.)	The content of a.i.	Group
High-dense crop				
1	Pirimor 500 WG	pirymicarb	500 g/l	Insecticide
2	Sadoplon 75 WP	thiram	75%	Fungicide
3	Redlan 400 EC	chlorpyriphos--methyl	400 g/l	Insecticide
4	Pennfluid 420 SC	mancozeb	420 g/l	Fungicide
5	Owadofos Extra 480 EC	chlorpyriphos	480 g/l	Insecticide
Medium-loose crop				
6	Sparta 250 EW	tebuconazole	250 g/l	Fungicide
7	Ammo Super 100 EW	z-cypermethrin	100 g/l	Insecticide
8	Bumper 250 EC	propiconazole	250 g/l	Fungicide
9	Captan 80WG	captan	80%	Fungicide
10	Mospilan 20 SP	acetamiprid	20%	Insecticide
Low Crop				
11	Roundup max 680 SG	glyphosate	680 g/l	Herbicide
12	Starane 250 EC	fluroxypyr	250 g/l	Herbicide
13	Chwastox 750 SL	MCPA-DMA	750 g/l	Herbicide
14	Amistar 250 SC	azoxystrobin	250 g/l	Fungicide
15	Mythos 300 SC	pyrimethanil	300 g/l	Fungicide

Data analysis

The operator exposure data were analyzed using STATISTICA 7,0 statistical software: ANOVA followed by HSD Tuckey multiple ranging test were carried out. The data for experienced operator exposure was used in National Institute of Public Health - National Institute of Hygiene to calculate the operator risk for 15 pesticides, representing different toxicity. The BBA mathematic model was used to assess the predicted operator exposure level (dermal and inhalation exposure during mixing/loading and spraying), expressing in mg/kg bw/day, taking into account: application method, product and formulation type, PPP dose, level of dermal absorption from product (typical for product), risk during mixing/loading and during spraying, work rate in ha/day and operator body weight 70 kg. The output data from in sillico modeling expressed the operator exposure in milligrams per kg of the operator body weight per day – in the same way as the AOEL data are expressed. Then the percentage ratios of the appropriate "per day exposure" and "per day AOEL's" were calculated. The Exposure/AOEL ratio 100 or less indicated that there is no risk for the operator. The pesticides used for in sillico modeling are listed in the table 2.

Results and Discussion

The lowest total operator exposure was measured for low crop sprayed by experienced operator using undamaged sprayer or equipped with damaged nozzle one (103.9 and 104.9 ppm, tab. 3). The highest total exposure (3110.4 ppm) was observed for high-dense crop, sprayed by experienced operator with the sprayer having damaged gun valve. During spraying the medium-loose crop, especially for inexperienced operator, in some cases, the exposure was greater than during spraying high-dense crop. The partial exposure ranged from 24.4 to 2477.6 ppm and the observed relations were similar to those for the total operator exposure (tab. 4). Although big differences of operator exposure measured for experimental combinations, the statistically significant differences were observed only in few cases. One of the most important reasons for lack of significant differences was probably big variability of measured exposition values in individual locations on the overall.

Tab. 3. Total operator exposure of the experienced and inexperienced operators during knapsack sprayer application in low, medium-loose and high-dense crops.

Operator	Sprayer condition	Crop					
		Low		Medium-loose		High-dense	
Experienced	Undamaged	104,9	a	712,1	a-c	209,5	a
	Gun valve damaged	201,3	b	1089,4	bc	3110,4	b
	Nozzle damaged	103,9	a	432,7	ab	931,7	a
Inexperienced	Undamaged	300,8	c	205,3	a	430,0	a
	Gun valve damaged	177,5	ab	1404,1	c	720,7	a
	Nozzle damaged	755,9	d	952,9	bc	366,1	a

Means in columns followed by the same letter do not differ significantly (HSD Tuckey Test, P<5%).

Tab. 4. Partial operator exposure of experienced and inexperienced operators to spray during knapsack sprayer application in low, medium-loose and high-dense crops.

Operator	Sprayer condition	Crop					
		Low		Medium-loose		High-dense	
Experienced	Undamaged	24,4	a	380,0	ab	146,3	a
	Gun valve damaged	38,9	a	378,7	ab	2477,6	b
	Nozzle damaged	30,8	a	273,7	ab	762,4	a
Inexperienced	Undamaged	40,8	a	120,2	a	296,7	a
	Gun valve damaged	31,1	a	732,9	c	373,6	a
	Nozzle damaged	44,5	a	489,4	bc	228,5	a

Means in columns followed by the same letter do not differ significantly (HSD Tuckey Test, P<5%).

The *in sillico* modelling was based on the exposure data for experienced operator from tab. 3. The highest exposure increase was observed in high-dense crop: 14.8 - fold for broken valve and 4.44 times for broken nozzle, less for the medium-loose crop 1.5 and 0.6 and in low crop 1.91 and 0.99 respectively. The values less than 1.0 denotes decrease of the operator exposure for broken sprayer.
The *in sillico* modelling showed that the influence of the sprayer technical condition on the increase of the risk for the operator (exceeding of the AOEL values) depends on the crop height and the Personal Protective Equipment usage (tab. 5). For the case with Personal Protective Equipment, in low and medium-loose crops, there was no influence of the sprayer technical condition on the exceeding of the AOEL values. That conclusion may support the opinion that there is no need to inspect knapsack sprayers in the context of operator risk. In that case it is enough to wear the PPE to protect the operator during application and preparation of spraying mixture. For pesticides 7, 8, 10, 11, 12, 14 there was no need to wear PPE neither for the efficient knapsack sprayer nor for the broken one. For the pesticides 6, 9, 13 and 3 in high crop the PPE should be used also for efficient sprayer.
In the high crops the knapsack sprayers should be used in the limited extent. For pesticides 2 and 5 the knapsack sprayers should not be used in such extent as the BBA model assumes, even for efficient sprayer.

Tab. 5. The operator exposure as a percentage of the AOEL value (%) for three technical conditions of the knapsack sprayer and three heights of the crops. Cases: without and with Personal Protective Equipment (No PPE / with PPE).

AOEL mg/kg/ day	Pesticide [nunber] name	Efficient Sprayer	Damaged Nozzle	Damaged Valve
High-dense crop – No PPE / with PPE				
0,035	[1] Pirimor 500 WG	83/17	368/76	1226/254
0,02	[2] Sadoplon 75 WP	2400/315	10656/1399	35520/4662
0,01	[3] Redlan 400 EC	200/50	888/222	2960/740
0,035	[4] Pennfluid 420 SC	46/23	710/355	2368/1184
0,01	[5] Owadofos Extra 480 EC	900/140	1142/178	3806/592
Medium-loose crop – No PPE / with PPE				
0,03	[6] Sparta 250 EW	267/10	160/6	400/15
0,02	[7] Ammo Super 100 EW	50/2,5	30/2	75/4
0,1	[8] Bumper 250 EC	10/0,8	6/0	15/1
0,1	[9] Captan 80WG	200/30	120/18	300/45
0,124	[10] Mospilan 20 SP	15/1,6	9/1	23/2
Low Crop – No PPE / with PPE				
0,2	[11] Roundup max 680 SG	25/5	25/5	48/10
0,8	[12] Starane 250 EC	21/1	21/1	41/2
0,04	[13] Chwastox 750 SL	200/17,5	198/17	382/33
0,1	[14] Amistar 250 SC	40/2,7	40/3	76/5
0,12	[15] Mythos 300 SC	92/14	91/14	175/27

Conclusion

The methodology used for risk assessment during PPP registration procedure may help in deciding about the need of knapsack sprayer inspection. The scale/extent of use in particular crop types/ heights should be taken into account before taking the final decision on the exemption of the knapsack sprayers from the inspection.

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New regulation concerning inspection intervals and exceptions of pesticide application equipment

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Summary

State Phytosanitary Administration (SPA) is the National Plant Protection Organization which is involved in the preparation of legislation for handling of pesticides within the implementation of Directive 2009/128/EC. The application equipment department of the SPA dealt with legislative matters in the field of pesticide application equipment (PAE) inspection in use. This department has been repealed and its activities took over the unit of SPA which solves with pesticides registration in the CZ.

Introduction

Directive no. 128/2009/EC establishes rules for carrying out regular inspection of PAE in use. Article no. 8/3 states that 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:

- apply different timetables and inspection intervals, ….
- exempt from inspection handheld pesticide application equipment or knapsack sprayers.

Field sprayers, air-assisted sprayers for orchards, vineyards and hop-fields, seed dressers, equipment for railway and aerial application equipment are obligate to inspection in the CZ. Brand new sprayers must be firstly inspected at the latest by the end of the two years after they were taken into use on the present.

Requirements and methods for the inspection of sprayers are conformed to EN 13790 Agricultural machinery – Sprayers – Inspection of sprayers in use – Part 1,2 (now under revision in CEN). Requirements for seed dressers, equipment for railway and aerial application equipment are stated only on the national level. Requirements for the inspection of manually operated machines are now ready on the national level. Handheld pesticide equipment and knapsack sprayers will be exempt from the inspection. This exception (in this version) is ready for a change in legislation in this area.

Conclusions

The legislation proposal is subject to the approval process in the Ministry of Agriculture. The form and content as presented on 4th SPISE may also be change significantly.

Risk assessment for human health and the environment - - SPISE Working Group - Proposal -

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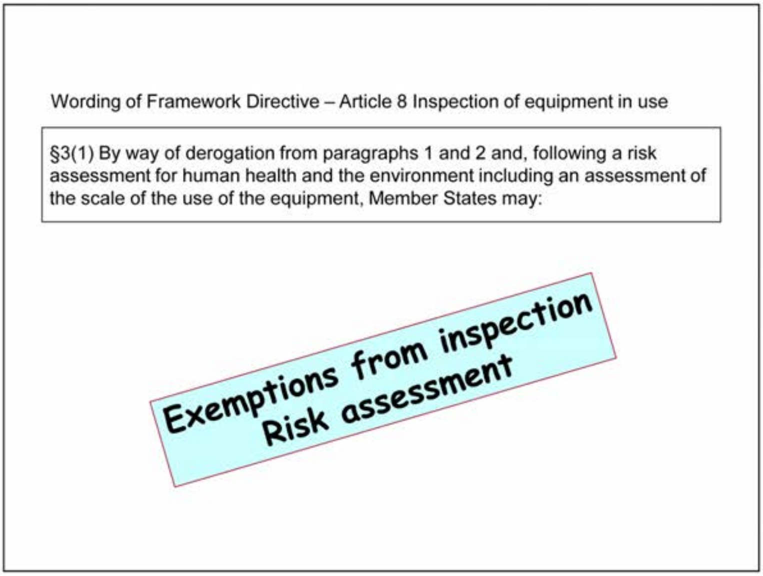
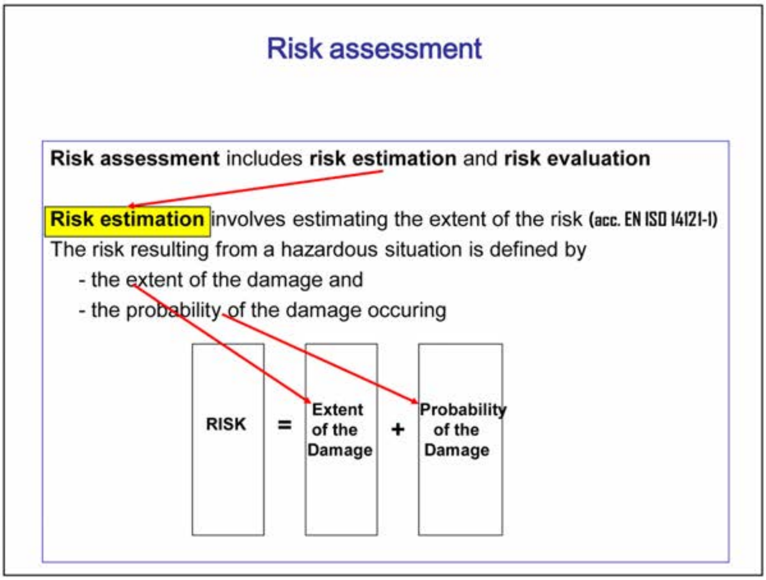
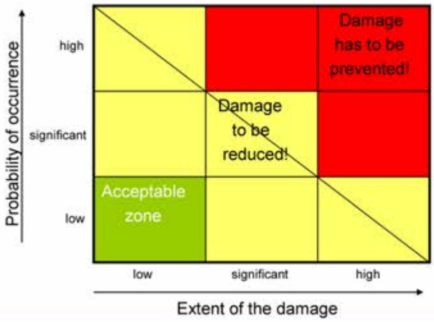
Member States may apply different timetables and inspection intervals in exceptional cases following a risk assessment for human health and the environment including an assessment of the scale of the use of the Pesticide Application Equipment (PAE) (according Article 8 (3)).
The SPISE Working Group (SWG) proposed an assessment of the risk for human health and the environment, including an assessment of the scale of the use.
The aim of this initiative is to convince the Member States of a comparable risk assessment which is scientifically based, transparent and variable and complies with current scientific and technical knowledge. This principal approach has proved to be successful in many other areas technology and should therefore be able to be transferred to PAE.
This initiative by the SWG is welcomed by DG-Sanco and should definitely be developed further.
Risk evaluations are also carried out in many other technical areas. They are used as a basis for deriving and discussing a risk evaluation for PAE.
Risk assessment includes risk estimation and risk evaluation.
Risk estimation involves estimating the extent of the risk.
The risk resulting from a hazardous situation is defined by the extent to the damage and the probability of the damage occurring.
The <u>extent of the damage</u> can be estimated for the relevant PAE taking into consideration the relevant ISO/EN norm for inspections for this equipment. With the help of a points system which is based on the equipment components, the hazard potential can be calculated with regard to occupational safety and the environment. If this approach is transferred to the relevant types of PAE constructions, it will lead to a sequence of equipment with regard to the extent of damage they cause.
The <u>probability of occurrence</u> is influenced by several factors. If the probability of occurrence cannot be stated, the frequency of happenings can be used instead. It is proportional to the amount of equipment used in practice and varies between the types of construction and the Member States.
The risk assessment can determine which type of the relevant PAE has a low, a significant and a high risk with regard to occupational and environmental protection and allow to classify the necessity of an inspection as low, necessary or high.
To this end a risk matrix is compiled to carry out a risk which is verifiable and comprehensible according to Nohl. It combines the criterion of possible severe damage with the criterion of the probability of occurrence. The risk areas vary in appearance depending on the assessment criteria used, as shown in the power point presentation. These Fig.s/matrixes have to be discussed and modified, taking into consideration the situations in the Member States.


Wording of Framework Directive – Article 8 Inspection of equipment in use
§3(1) 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:
Exemptions from inspection
Risk assessment


Risk assessment
Risk assessment includes risk estimation and risk evaluation
Risk estimation involves estimating the extent of the risk (acc. EN ISO 14121-1)
The risk resulting from a hazardous situation is defined by
- the extent of the damage and
- the probability of the damage occuring
RISK
=
Extent of the Damage
+
Probability of the Damage

Risk estimation

The **risk matrix** according to Nohl & Thiemecke [1] shows a verifiable and comprehensible way to combine the criterion of the possible extent of damage with the criterion of the probability of occurrence.



[1] Systematik zur Durchführung von Gefährdungsanalysen, Verlag für neue Wissenschaft 1988

Risk estimation

How to calculate the extent of damage?

The **extent of the damage** can be estimated for the relevant PAE (acc. classification scheme) taking into consideration the relevant ISO/EN Standards (acc. EN 13790) for inspection for this equipment.

1) Pesticide Appl. Equipment (PAE) used for spraying (incl. fogging)
2) hand-operated PAE
3) PAE not used for spraying
4) handheld PAE
5) knapsack sprayer
6) additional PAE
7) spray train
8) aircraft

Risk estimation

With the help of a **point system** which is based on the equipment components, the extent of the damage can be calculated with regard to the human health and the environment.
If this approach is transferred to the relevant types of PAE, it will lead to a sequence of equipment with regard to the extent of damage they cause. This fig shows an example of how this can be done.

Equipment components \ Pesticide Appl. Equipment (PAE)	spraying (incl. fogging)	hand-operated	not used for spraying	
Power transmission parts	++	+	o	
Pump	+	+	+	
Agitation	+	+	o	
Spray liquid tank	++	+	+	
Pipes and hoses	+	++	++	
Spray boom	+	o	o	
Filter	o	o	o	

Risk estimation – Calculation of extent of the damage

JKI

Equipment components \ Pesticide Appl. Equipment (PAE)	spraying (incl. fogging)	hand-operated	not used for spraying	handheld	knapsack sprayers	additional	additional/ train	additional/ aircraft
Power transmission parts	++	+	0	- -	- -	0	+	+
Pump	+	+	+	0	0	0	+	+
Agitation	+	+	0	- -	-	-	++	++
Spray liquid tank	++	+	+	- -	- -	+	++	++
Pipes and hoses	+	++	++	- -	- -	0	++	++
Spray boom	+	0	0	- -	- -	-	+	++
Filter	0	0	0	-	-	0	0	0
Nozzles	++	++	+	-	-	0	++	++
Controls	0	0	0	-	0	0	+	+
Regulation systems	+	0	0	-	-	+	++	++
Distribution / drift	+	0	0	-	0	0	++	++
Cleaning	++	0	0	-	-	0	++	++
Blowers	+	-	-	-	-	-	-	-
Point system (very low -- 2,5; low - 5; Ø 0 10; high + 15; very high ++ 17,5)	195	160	147,5	57,5	70	140	197,5	200
	3	4	5	8	7	6	2	1
Point system (very low -- 0; low - 5; Ø 0 10; high + 15; very high ++ 20)	205	165	150	45	60	125	215	230
	3	4	5	8	7	6	2	1

Point system:

very low	low	Ø	high	very high
- -	-	0	+	++
2,5	5	10	15	17,5

very low	low	Ø	high	very high
- -	-	0	+	++
0	5	10	15	20

Sequence according the extent of the damage

Risk estimation

How to calculate the probability of damage?

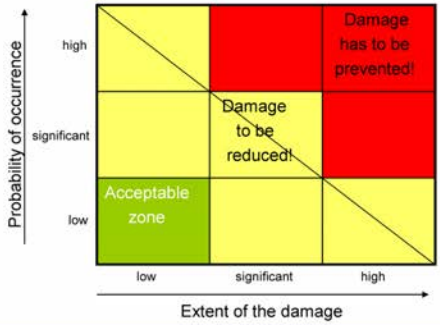
The **probability** of the damage (= probability of occurrence) is influenced by several factors.
If the probability of occurrence cannot be stated, the frequency of incidents can be used instead. It is proportional to the amount of equipment used in practice and varies between the types of equipment and the Member States.

Risk estimation involves estimating the probability of the damage

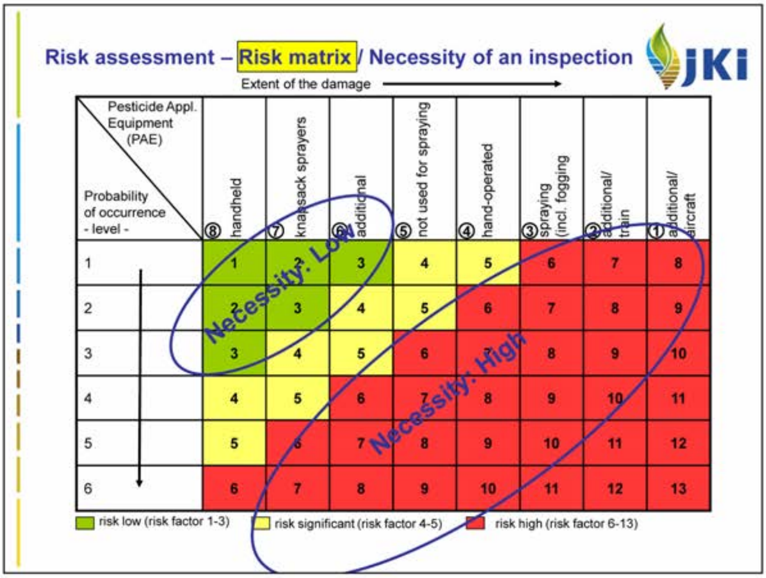
RISK	=	Extent of the Damage	+	**Probability of the Damage**

Risk estimation

The **risk matrix** according to Nohl & Thiemecke [1] shows a verifiable and comprehensible way to combine the criterion of the possible extent of damage with the criterion of the probability of occurrence.



[1] Systematik zur Durchführung von Gefährdungsanalysen, Verlag für neue Wissenschaft 1988



Risk assessment – Risk matrix / Necessity of an inspection

Extent of the damage →

Pesticide Appl. Equipment (PAE) / Probability of occurrence - level -	⑧ handheld	⑦ knapsack sprayers	⑥ additional	⑤ not used for spraying	④ hand-operated	③ spraying (incl. fogging	② additional/ train	① additional/ aircraft
1	1	2	3	4	5	6	7	8
2	2	3	4	5	6	7	8	9
3	3	4	5	6	7	8	9	10
4	4	5	6	7	8	9	10	11
5	5	6	7	8	9	10	11	12
6	6	7	8	9	10	11	12	13

Risk assessment

The **risk assessment** can determine which type of the relevant pesticide application equipment has

- a low,
- a significant and
- a high risk

with regard to human health and environmental protection.
The **risk zones** vary depending on the assessment criteria used.

In a second step a classification regarding the necessity of an inspection as

- low,
- necessary or
- high

can be made.
These figures have to be discussed and modified, taking into consideration the situations in the Member States (e.g. amount of PAE)

Session 3: The inspections shall verify that pesticide application equipment satisfies the relevant requirements

Introduction paper

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Summary
Accordingly to EU Directive EC128, pesticide application equipment may satisfy minimum requirements listed in Annex II in order to achieve a high level of protection for human health and the environment. A second aspect refers to harmonized standards precised in article 20 (1) with a principle of presumption of conformity. Finally it is also possible to propose alternative methods as potential tools for sprayer inspection.

Introduction
The application of the EU Directive on sustainable use of pesticide implies essential requirements to be fulfilled by pesticide application equipments. In parallel, each member state has to comply with such requirements when the EU directive is in the national transcription phase. Existing standards may deliver guidance to specifications, measurements and thresholds if adapted. The European Commission can mandate the CEN to deliver relevant standard in conjunction with ISO.
The Directive states that *"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."
In addition , the general requirements are listed in the Annex II of EU Directive 2009/128/CE
Main Objectives are Health, Safety & Environment and rely on several items :

- Reliability of teh equipment
- Use in conformity : precision in CPP dosage and spraying
- Safe easy and complete filling and emptying, avoid leakages
- Safe handle easy & throughout cleaning. Control and stop immediately from the operator place.
- Simple , accurate and reproductible adjustments

1- Principle of sprayer inspection in France
Following EU Directive requirements, sprayer inspection in France is introduced. It is commonly divided in 10 chapters and the evaluation can be visual check, function test or measurement (Fig. 1).

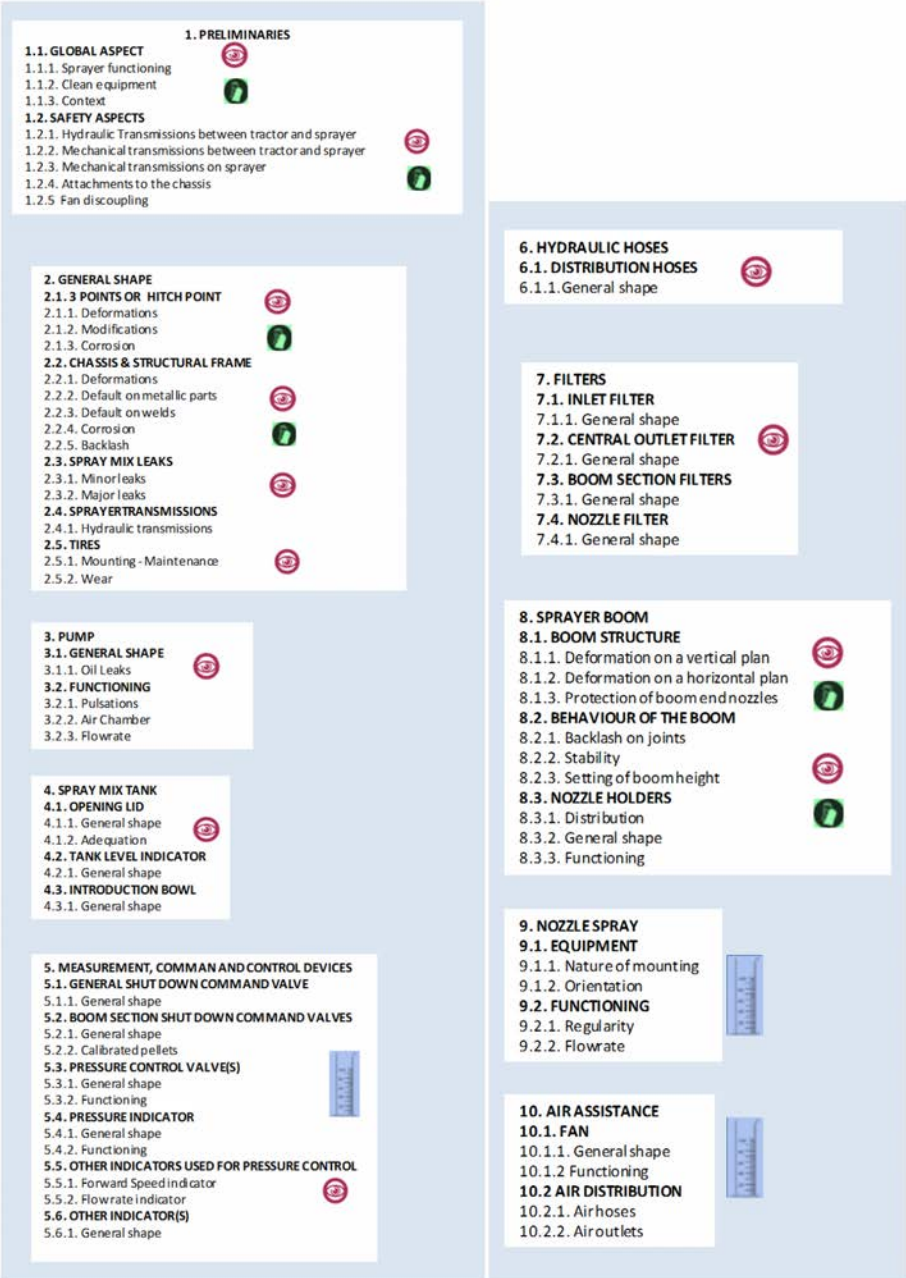

Fig. 1. Chapters of Sprayer Inspection in France. GIP Pulvés Document.

2. Harmonized standards

In parallel to the application of the EU directive, the European Commission mandated the CEN (European Committee for Standardization) to deliver relevant and updated standards.
The following table introduces the evolution of EN/ISO standards (Tab. 1)

Tab. 1.

Topic	Current reference	Future reference	Sub part	Expected publication date*
Inspection of new sprayers	EN/ISO 12761 series	EN/ISO 16119 series	Part 1 : general	March 2013
			Part 2 : horizontal boom sprayers	March 2013
			Part 3 : sprayers for bushes and orchard	March 2013
			Part 4 : Fixed and semi mobile sprayers	November 2014
Inspection of sprayer in use	EN/ISO 13790 series	EN/ISO 16122 series	Part 1 : general	August 2015
			Part 2 : horizontal boom sprayers	August 2015
			Part 3 : sprayers for bushes and orchard	August 2015
			Part 4 : Fixed and semi mobile sprayers	November 2014

*Reference July 2012

Such standards can be considered as references for protocols and threshold values to be obtained.

Conclusion

The investigation of those aspects regarding essential requirements, standards, and methods, is devel-opped through 3 presentations :

1- Development of ISO/EN standards regarding the inspection of sprayers,
J.-C. Rousseau (France)
2- Sprayer tank agitation check: A proposal for a simple instrumental evaluation,
P. Balsari, M. Tamagnone, D. Allochis, C. Bozzer (Italy)
3- Inspection method for spray rate controllers in Flanders (Belgium),
J. Declercq, D. Nuyttens (Belgium)

Development of harmonised standards on environment for new sprayers

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DOI 10.5073/jka.2012.439.014

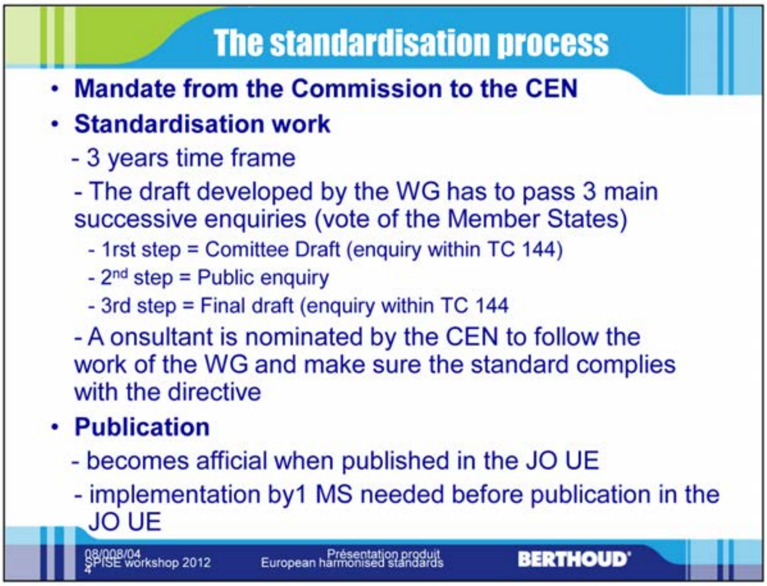
With the entry in force of the Thematic Strategy on sustainable use of pesticides, both new and in use sprayers have now also to comply with European regulations related to the respect for environment. Since the15th of December 2011, new sprayers have to comply with the amendment to the Machinery Directive under the process of self certification. New European harmonised standards are therefore needed to support the manufacturers in implementing this new regulation.

A new series of standards (EN ISO 16 119) that defines environmental requirements on new sprayers is under development since 2009. The work started with general requirements (16 119-1), horizontal boom sprayers (ENISO 16 119-2) and vineyards and orchards sprayers (16 119-3) on the basis of the existing EN 12 761 standard developed in the 90's, A fourth part (EN ISO 16 119-4) has also been initiated. Some additional parts for other specific types of sprayers could be added in the future.

These standards are developed by the CEN Technical committee "Agricultural and forestry machinery" (CEN TC 144) , Working Group 3 "Mobile machines" with the participation of the ISO subcommittee on plant protection equipment (ISO TC 23/SC6), which means they will be published both as European and International standards (respectively EN and ISO standards).

This work on new sprayers is done in parallel with the development of the standards for the inspection of sprayers in use (EN ISO 16 122) in order to avoid inconsistency between requirements on new and in use sprayers.

The 3 first parts of ENISO 16 119 have now passed the parallel EN / ISO public enquiry and could possibly be published in the Official Journal of the UE during 2013.




ISO standards
• International scale standards
• TC23: Technical committe « Tractors and machinery for agriculture and forestry »
• SC6: Sub committee within TC23 « Equipment for crop protection)
• 30 countries are member of SC6
• 36 existing standards + 7 under development
• Test methods, classification scales, coding, performance criteria and limits…
• Machines, systems or components
• Focus on environmental issues since 15 yeras
• EN standards refer very often to ISO standards
• More and more standards are developped in common betweenCEN and ISO (EN ISO standards)
• Similar development process as for EN standards
08/008/04
SPISE workshop 2012
Présentation produit
European harmonised standards
BERTHOUD


ISO standards
New sprayers
►Environmental requirements
Sprayers in use
► Inspection
Distribution
►Test methods and spray deposits measurements
Boom
►steadiness
Test methods
► test methods for hydraulicc sprayers and volume/ha adjustment systems
Drift
►Measurements and classification of sprayers
Cleaning
► test methods for internal, and external cleaning
► Drainable volume measurement
Nozzles
►Coding, test methods and droplet size measurements
Induction hoppers
►Test methods and performance limits
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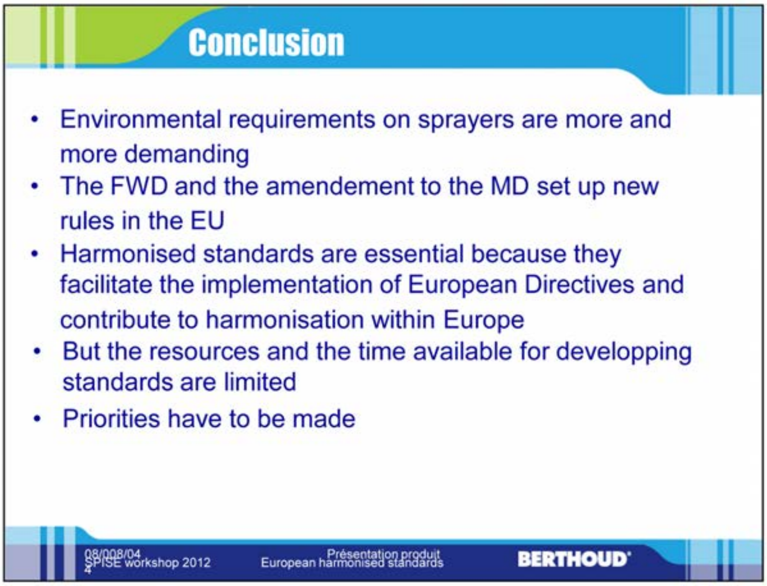
Conclusion
• Environmental requirements on sprayers are more and more demanding
• The FWD and the amendement to the MD set up new rules in the EU
• Harmonised standards are essential because they facilitate the implementation of European Directives and contribute to harmonisation within Europe
• But the resources and the time available for developping standards are limited
• Priorities have to be made
SPISE workshop 2012
European harmonised standards
BERTHOUD

Sprayer tank agitation check: A proposal for a simple instrumental evaluation

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Abstract
The performance of the sprayer agitation system has an important effect on both pesticide distribution quality and environmental contamination. The visual inspection of sprayer tank agitation systems during inspections of sprayers in use could not give enough precise and repeatable information also due to the human factor.
With the aim to provide more reliable and objective results for the equipment already in use, experiments were carried out for individuating instruments and methods enabling to make a simple and quick evaluation of sprayer tank agitation systems efficiency. Use of a solid inert tracer (glass microspheres) characterized by high sedimentation velocity, to be inserted with the water in the main tank, was found suitable to provide useful information about the efficiency of tank agitation systems in a quick and reproducible way. Further tests are in course in order to confirm the reliability of results obtained using this tracer and to define the details of a test methodology to propose for inspections of sprayers in use.

Introduction
Inspections of sprayers in use, that are now mandatory according to the prescriptions of EU Directive 128/2009/EC, foresee several checks on main sprayer components in order to verify their proper functioning.
Among the assessments to carry out, the check of sprayer tank agitation system is very important.
Several studies (He *et al.*, 1999; Ucar *et al., 1999;* Ucar *et al., 2001*), have pointed out that only with a correct agitation of the spray mixture in the tank it is possible to achieve a good efficacy of the spray application and it is possible to minimize pesticide losses. Due to this fact, the assessment of the tank agitation system during inspections of sprayers in use is mandatory and must result positive in order to pass the inspection.
Actually, two different procedures are adopted to evaluate the tank agitation systems for new sprayers and for sprayers in use. For brand new sprayers the ISO standard 5682-2 is applied: it requires to use a copper oxychloride (1% w/w) suspension as test material. Samples of spray mixture are taken after 10 minutes agitation at three levels of the tank in order to establish a reference copper concentration and then the spray mixture is left in the tank without any agitation for 16 hours before making a second sampling that is carried out after 10 minutes agitation. Comparing the reference copper concentration assessed in the samples taken just after the introduction of the test material in the tank and the one of samples taken after 16 hours it is possible to make an evaluation of the efficiency of the tank agitation system. This method, however, is long and is not suitable for inspections of sprayers in use. In this latter case, actually, according to ISO DIS 16122, just a visual assessment is carried out, but this is not an objective measurement of the tank agitation functioning.
In order to get a quick, objective and reproducible evaluation of the efficiency of the tank agitation system a study was therefore carried out at DEIAFA – University of Torino, aimed at defining an ad hoc test methodology also applicable in the inspections of sprayers in use.
Two different approaches were considered:

a) The assessment of the liquid turbulence inside the sprayer tank using specific instruments able to register the liquid movements in different parts of the tank;

b) The measurement in different parts of the tank of the concentration of a solid tracer mixed in the water, featured by a high sedimentation velocity.

Materials and methods
2.1. Devices to measure liquid turbulence in the tank
First phase of tests was addressed to evaluate the use of three different types of sensors, featured by the same principle of functioning (magnetic sensor or phonic wheel) but having different shapes and made of different materials.

The first instrument tested was realised using three flow meters "Wolf" model manufactured by Arag company. They are made of polypropylene and polyamide and consist of an electronic sensor able to measure the movement of a wheel equipped with small blades having its rotation axis transverse with respect to the liquid flux direction. Sensors have the capacity to measure in both directions and are featured by a measurement range of 10÷200 l/min (Fig. 1).
The three flow meters were mounted in series on a metal telescopic support 150 cm long, at 15 cm spacing, therefore enabling the simultaneous detection of the liquid movement at three tank levels and allowing the measurement of the liquid flow from different directions, thanks to the possibility to rotate sensors and their support along the vertical axis (Fig. 2).
For each sensor, measured liquid flow rate values (l/min) detected in the measuring points were read on a "Digiblock 2" display manufactured by Arag (Fig. 3).
The second instrument tested consists of a cylindrical axial fan flow meter equipped with a magnetic sensor which is attached to a speed measuring system (having a range of 0-11 m/s). The sensor axial fan is 98 mm diameter and is provided with 12 small blades, it can rotate in both directions (clockwise or anticlockwise) and it is mounted in correspondence of the centre of a cylindrical structure 150 mm long and featured by a 130 mm external diameter (Fig. 4).
The cylinder was fixed at the edge of a metallic pole 150 cm long, in order to allow its positioning in different parts of the tank.
The third device used in the tests was realized with a cup sensor like the ones used for anemometers, linked to a speed measuring system, similar to the one applied to the second instrument, having a range 0-11 m/s (Fig. 5). Tests were carried out with two different cup sensor sizes: the first one had an overall diameter of 150 mm while cup diameter was 43 mm and cup depth was 22 mm; the second one was featured by an overall diameter of 120 mm, cup diameter of 28 mm and cup depth of 15 mm.
All the three instruments were employed to make measurements inside two tanks: a) a 200 l capacity tank of a mounted sprayer; b) a 2000 l capacity tank of a trailed sprayer (Tab. 1)

Tab. 1. Main features of the tanks used for the determination of the liquid turbulence.

Volume (l)	Tank depth (cm)	Kind of agitation system	Pump capacity (l/min)	Pump model	N° of agitation points
200	75,5	Backflow	max 70	Comet APS71	1
2000	111	Venturi system (1) and backflow	max 140	Comet IDS1400	2

Fig. 1. Flow meters "Wolf" model manufactured by Arag company and example of a paddlewheel sensor.

Fig. 2. Telescopic support for the flow meters enabling to measure liquid flows at different levels and from different directions.

Fig. 3. Displays "Digiblock 2" manufactured by Arag company for visualization and registration of flowrate measurements.

Fig. 4. Second type of sensor instrument equipped with an axial fan flow meter in a cylindrical body.

Fig. 5. Third type of sensor instrument, equipped with cup anemometer sensors.

Tests carried out using the three different instruments were made filling the tanks up to half of their nominal capacity (100 l and 1000 l respectively) with clean water, then activating the agitation system at a pump working pressure of 15 bar and a PTO revolution speed of 540 rev/min.
Sensors were positioned in predetermined positions inside each tank following a reference measurement grid as shown in Fig. 6.

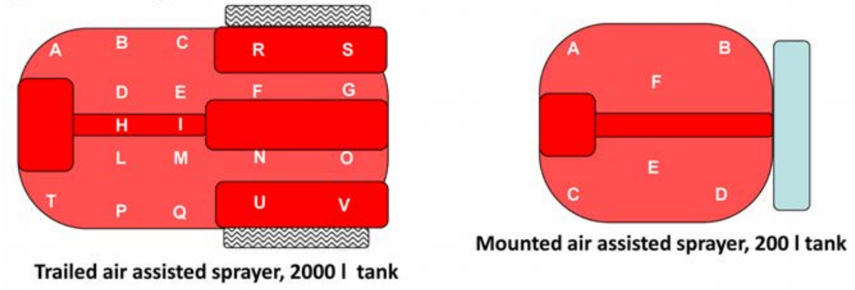

Fig. 6. Measuring positions used as reference in the two tanks examined.

For each point of the grid, measurements were taken at three different liquid levels: 1) close to the tank bottom; 2) in correspondence of the surface liquid level; 3) at an intermediate level between 1) and 2).

2.2. Use of an inert solid material as tracer inside the tank
Preliminary tests were made to individuate the most suitable inert material to employ in the tank agitation assessments: three different tanks were examined, two having a 200 litres capacity and applied on mounted vineyard air-assisted sprayers, one having a 600 litres capacity and applied on a mounted field crop sprayer (Table 3). The following requirements and characteristics were searched for the test material:

Reduced or null abrasiveness: the material shall not damage sprayer components during its agitation in the tank.
Inertia: the material shall not be subjected to any physical or chemical reaction, it has to be not harmful for users and the environment.
High sedimentation velocity: the material shall not remain suspended in water for a long time without liquid agitation. This parameter is related to its density and particle size.
Particle size: size of particles constituting the material shall be smaller than mesh size of filters usually mounted on agricultural sprayers so to avoid eventual filter blockages.
Easy commercial availability: the material shall be available at low cost, in order to be used on a wide scale by test stations charged of inspections of sprayers in use.

Taking into account these characteristics, three different materials were selected for preliminary tests: clay dust (kaolin); vegetal residues (corn cob and nutshell powder); microspheres of sodium calcic glass (Table 2).
Kaolin is a type of clay that was already used in the past for assessing performance of sprayer agitation systems (Ucar *et al.,* 1999), as it is also employed as a carrier in several plant protection products formulated as wettable powders.
Tests were carried out using two kaolin based products, featured by the same bulk density (2.6 g/cm^3) but with different particle sizes (1-2 µm and 4-6 µm respectively).
Vegetal residues were featured by higher particle size, that was 180÷400 µm for nutshells and 100÷200 µm for corn cob, while their density ranged from 0.9 to 1 g/cm^3.
Glass microspheres had a particle size of 90÷150 µm and were featured by a density (2.5 g/cm^3) very close to the kaolin one.
After the selection of test materials, the measurement method for assessing the amount of inert material collected in the tank samples was defined. A comparison between different graduated containers filled with the same amount of material was carried out in order to verify their precision and practicality in reading measures.

Results indicated that volumetric glass flasks 500 ml capacity were most suitable in providing accurate measurements of solid sediments, when they were used upturned in order to concentrate the sediment in the flask neck.

Tracer		Bulk density ($g\ cm^{-3}$)	Nominal particle size (µm)	Composition	Concentration	Sedimentation time (s)
Clay dust	Inert kaolin	2,6	1-2	Kaolin (Fe and Al mixed silicates)	1,0%	600
	Commercial kaolin	2,6	2-4	Kaolin (95%) and colloids (5%)	0,6%	1200
Chopped vegetal residues	Nutshell powder	1,1	180-400	nutshell	0,7%	600
	Corn cob powder	0,9	100-200	corn cob	0,6%	900
Glass microspheres		2,5	90-150	soda-lime glass	5,0%	120

Tab. 2. Materials tested as tracer for assessing efficiency of sprayer tank agitation systems

A further step to set up the test methodology using inert solid materials was to determine the tracer concentration to be used in the tank, enabling to detect sediments in the graduated flasks. For each test material examined, the concentration value was individuated introducing in the flasks a known amount of tracer, in order to have a set of samples featured by known and increasing concentrations. Sedimentation level was then observed upturning the flasks and leaving the tracer sediment for a certain time interval (Fig. 7).
Through these analysis, for each tracer, it was therefore possible to determine:

- The optimal concentration related to the sedimentation levels that can be easily observed;
- The sedimentation time intervals needed to read the sediment level in the samples.

Fig. 7. Sedimentation tests made to determine the tracer concentration and the reference sedimentation time for each tracer examined.

The test methodology set up to evaluate the performance of sprayer agitation systems by means of solid material was therefore subdivided in three phases:

Phase A): Tracer preparation and introduction in the sprayer tank

In order to avoid lumps during their introduction in the sprayer tank, tracer amounts used in the tests were first mixed with some water. Before adding the tracer, the sprayer tank was filled with clean water up to half of its nominal capacity. Tracer was introduced in the tank after that the agitation system was activated adopting a pump working pressure of 15 bar and a PTO revolution speed of 540 rev/min.

Phase B): Tank sampling.

Samples were taken out from the tank at least 5 minutes after the tracer introduction, keeping the agitation system activated, at three tank levels: close to the bottom, at middle liquid level and close to the liquid level surface. Sampling of liquid was made through a sucking device combined with a 12 V pump; for each sampling point three samples were picked up and introduced in the graduated flasks.

Phase C): Analysis of tank samples.

Just after the sampling, graduated flasks were upturned and placed in ad hoc supports provided with a graduated scale enabling to assess the amount of tracer deposit (Fig. 8).

Fig. 8. Graduated flasks containing the tracer suspensions upturned and positioned in supports provided with a graduated scale to read the amount of sediment deposited in the flask neck.

After the time necessary for the tracer to sediment in the flask neck, the amount of sediment was measured for each sample and it was compared with the reference one corresponding to the tracer concentration originally introduced in the sprayer tank.

Tests using the two types of kaolin were carried out comparing the samples taken from a tank with a nominal capacity of 600 l, filled with 300 l of water, either activating or not the tank agitation system (in the latter case the agitation of spray liquid was obtained just through the backflow). Two different tracer concentrations were used: 1% (w/w) for the first type of kaolin, 0.6% (w/w) for the second type.

When vegetal residues were used as tracer (nutshell or corn cob reduced in powder), tests were made in the same tank employed for trials with kaolin. Tracer concentration was 0.7% (w/w) for nutshell and 0.6% (w/w) for corn cob.

Tests made employing glass microspheres as tracer were carried out in three different tanks: a 600 l tank (the same used in the previous tests with the other tracers), a 200 l tank equipped with the agitation system and a 200 l tank without any agitation system.

Tracer concentration was 0.5% (w/w).

Tab. 3. Main features of the tanks employed for the evaluation of the tracers

Volume (l)	Tank depth (cm)	Kind of agitation system	Pump capacity (l/min)	Pump model	N° of sampling levels
200	75.5	Backflow	max 70	Comet APS71	3
200	100	Venturi system (1), flat fan nozzles, backflow	max 50	Comet APS51	3
600	114	Venturi system (3) and backflow	max 150	Comet BP151	3

3. Results and discussion

3.1. Devices to measure liquid turbulence in the tank

All the three types of sensors used to measure liquid turbulence in the tank resulted not able to provide acceptable and reliable results as the flow rate values registered were not constant and therefore it was not possible to evaluate the efficiency of the tank agitation system. Problems during measurements were mainly related to the difficulties in getting repeatable flow rate values: in the same point of the measuring grid in the tank (see Fig. 6) flow rates registered showed a very high variability over time. In some positions in the tank it was even not registered any flow rate (display value on the instrument was zero) despite liquid turbulence in those positions was visually evident. Turbulence of liquid in the tank was therefore not adequately described through the use of sensors. Moreover, the shape and size of tanks, especially of that with a reduced capacity (200 l), generated problems to operate with these sensors as their precise positioning resulted difficult, in particular in the measuring points located farer from the tank opening.

3.2. Use of an inert solid material as tracer inside the tank

Sedimentation tests made with the two different types of kaolin based materials showed not significant differences between the two tracers: for both material sedimentation time ranged between 600 and 1200 seconds.

Concerning the analysis of samples taken at different levels in the tank, no big differences were observed, but it was noticed that, increasing the time between the introduction of the tracer in the tank and sampling, the level of tracer sedimentation decreased.

An analogue decreasing trend was observed in the tests made with the tank agitation system disconnected as it is shown in the graph reported in Fig. 9.

In order to evaluate the causes of such phenomenon all samples were weighed and then dried in a heater at 110°C so to determine the amount of dried residue and to check the effective tracer concentration. Results pointed out that the concentration of kaolin was constant in the samples, so the decreasing of sedimentation level was due to the variation of the tracer particle size after its pass in the hydraulic circuit of the sprayer (Fig. 10).

As the test results obtained using the kaolin based tracers pointed out poor accuracy and repeatability due to the modification of the physical properties of the material, trials were suspended.

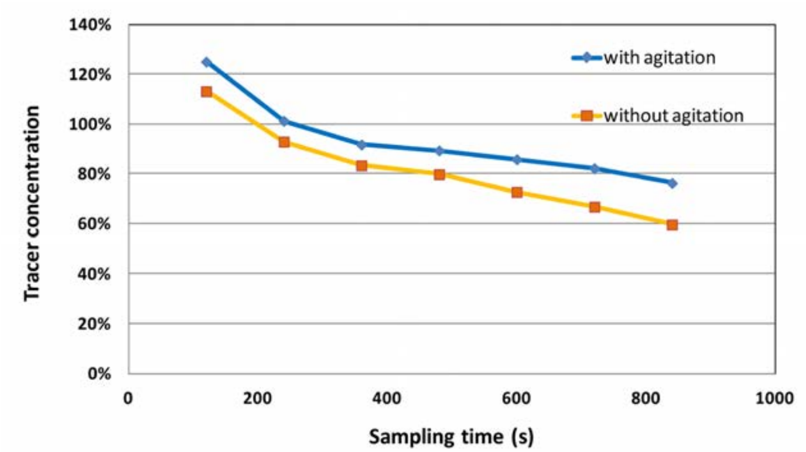

Fig. 9. Comparison between tracer concentrations measured in the tank samples after different sampling times, with and without the agitation system activated (600 l tank capacity).

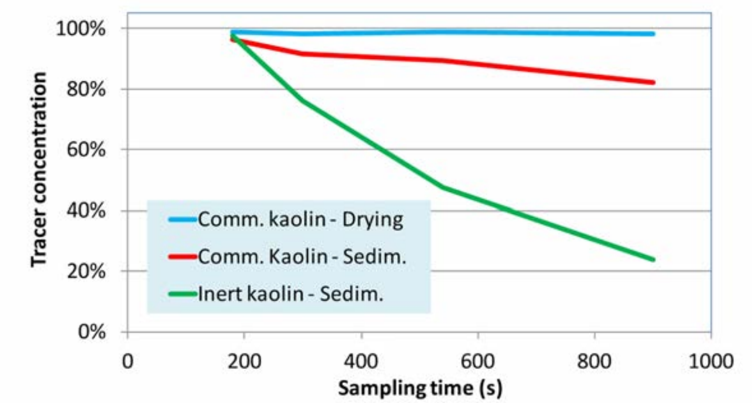

Fig. 10. Comparison between tracer concentrations measured in the tank samples after different sampling times, assessing the sedimentation levels in the flask necks or drying the samples in the heater.

The two tracers based on vegetal residues (nutshells and corn cobs) that were tested, even if they showed a good sedimentation velocity, were not suitable to be used use inside a sprayer tank as they caused blockages of filters and interfered with the regular functioning of the sprayer agitation system (Fig. 11).

Fig. 11. Example of filters obstructed with nutshell powder.

Tests made employing the glass microspheres showed a different tracer behaviour with respect to the previous tests, especially regarding the trials carried out with the sprayer agitation system activated (see Fig.s 12, 13, 14, 15 and 16). In comparison with the experiments done using kaolin based materials, values of tracer concentration measured during the test did not vary significantly but they resulted pretty constant as the physical characteristics of the material, particularly the particle size, were not influenced by the action of sprayer hydraulic circuit. Main problems encountered during the tests made with glass microspheres were related to the low tracer concentration detected in the samples taken in the upper part of the tank, close to the liquid surface, that sometimes resulted below 3% of the original reference value even if a proper agitation of the liquid was visible in that point.
This fact was due to the high sedimentation velocity of glass microspheres that just after 2 minutes from their introduction in the tank settle down towards the tank bottom.
At the intermediate level and at the bottom level of tank sampling the trend of results was different.
In the tanks equipped with the agitation system activated the tracer concentration measured in the samples taken close to the bottom of the tank resulted very high, sometimes over 100% vs. the reference concentration (Fig. 12), while at the tank intermediate level the tracer concentration resulted about 80-90% of the reference value (Fig. 14). These results showed a good efficiency of the agitation system.
On the contrary, in the third tank examined, featured by the lack of the agitation system, the tracer concentration values registered at the intermediate and at the bottom tank level resulted very low, ranging between 20% and 40% of the reference concentration close to the tank bottom and ranging between 5% and 7% at the intermediate tank level (Fig. 16). Similar results were obtained for the tanks equipped with the agitation system when the latter was not activated (Fig. 13 and 15).

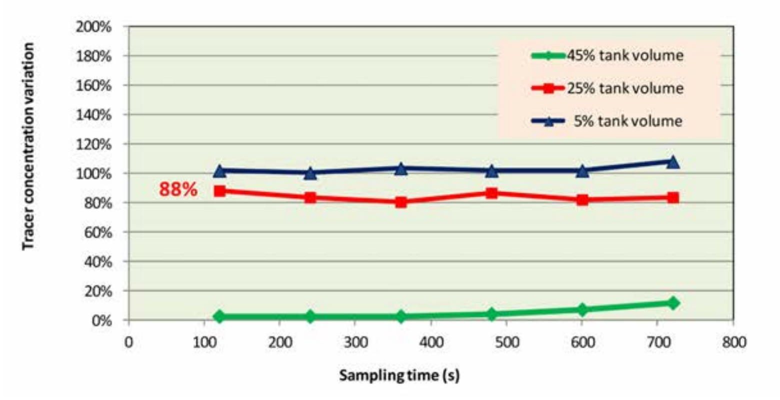

Fig. 12. Glass microspheres concentration in samples taken out of the 600 l tank when the agitation system was activated.

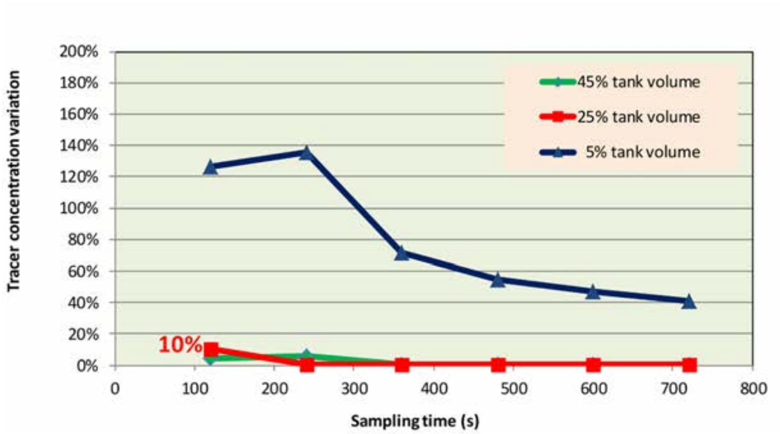

Fig. 13. Glass microspheres concentration in samples taken out of the 600 l tank when the agitation system was not activated.

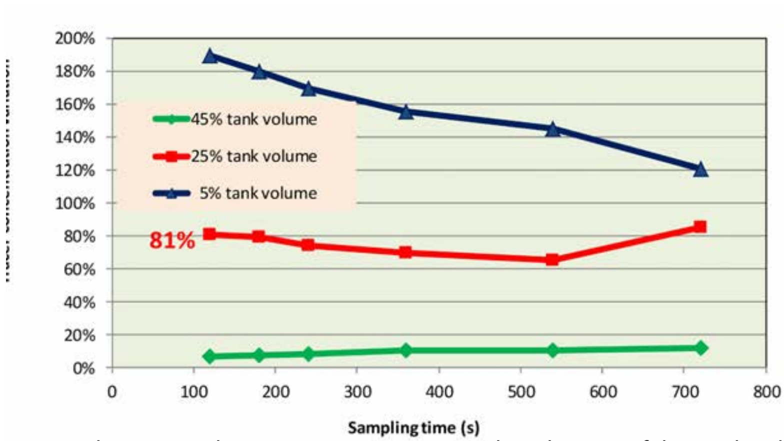

Fig. 14. Glass microspheres concentration in samples taken out of the 200 l tank when the agitation system was activated.

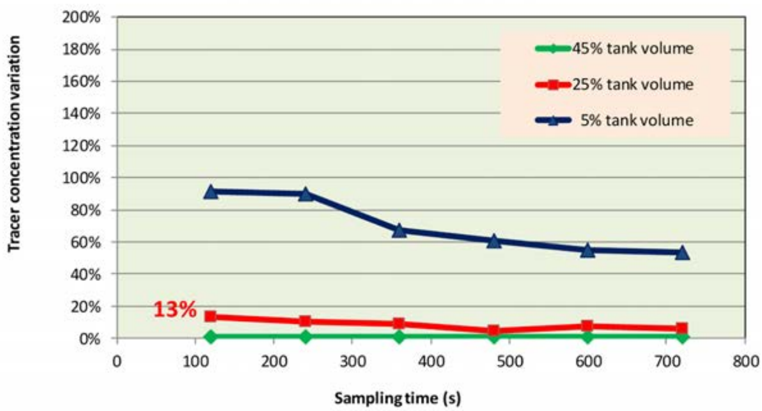

Fig. 15. Glass microspheres concentration in samples taken out of the 200 l tank when the agitation system was not activated.

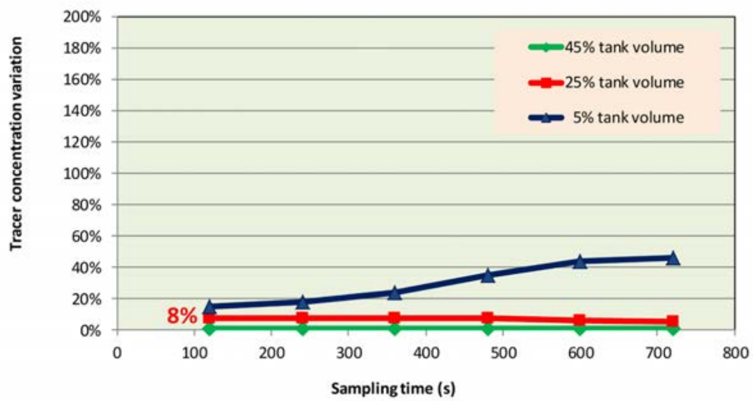

Fig. 16. Glass microspheres concentration in samples taken out of the 200 l lacking of any agitation system.

Conclusions

First part of tests made pointed out that the use of sensors to assess the liquid turbulence in the sprayer tanks was not suitable to obtain reliable and accurate indications about the efficiency of the tank agitation systems. This method was therefore not further considered for the assessment of efficiency of tank agitation systems in sprayers in use.

In the second set of experiments, instead, it was individuated a tracer (glass microspheres) enabling to provide in short time some general but reliable indications about the efficiency of the sprayer tank agitation systems. This enabled to set up a first proposal of test methodology that shall be refined and consolidated after some further tests and evaluations.

Physical properties (quick sedimentation velocity, null abrasiveness, particle size not interfering with the action of the sprayer hydraulic circuit) revealed glass microspheres suitable to be used as tracer for assessing tank agitation system efficiency. Moreover, the possibility to reuse the material for several tests is useful to save money and to limit problems of tracer disposal after use.

Actually further tests are in course at DEIAFA – University of Torino in order to verify the use of glass microspheres on a wider sample of sprayer tanks, to compare the results obtained using this new tracer with the ones obtained for the same tank applying the ISO 5682-2 test method (based on use of copper oxychloride), that is normally applied for testing of new sprayers. Moreover it is intended to verify if using finer glass microspheres their sedimentation velocity is reduced, so that a higher tracer concentration could be registered also in the top part of the tank.

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Inspection method for spray rate controllers in Flanders (Belgium)

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Summary

In Belgium, the inspection of sprayers is performed by official and mobile teams ruled by two inspection authorities. The management of the inspection is done by the Federal Ministry for Consumer Protection, Public Health and the Environment (FAVV). In the Flemish region the inspection is delegated to the Institute for Agricultural and Fisheries Research (ILVO). In Belgium, the mandatory inspection of sprayers was started up in 1996 and the 6th inspection cycle (2011-2012-2013) is currently running. In the past decade the number of sprayers equipped with a spray rate controller, increased significantly. In the first inspection cycle (1996-1997-1998), only 4.58% of the sprayers were equipped with a spray rate controller in Flanders. In the fifth inspection cycle (2008-2009-2010), this percentage increased significantly to 20.37%.
As the original inspection method for spray rate controllers showed some lacks and was time consuming, ILVO developed a simple and reliable method for testing rate controllers used on field and orchard sprayers.
Key words**:** sprayers, inspection, rate controller

Introduction

Since 1995 sprayer inspection is mandatory in Belgium which makes it one of the forerunners in Europe. The items that need to be inspected and the requirements are completely described in the Belgian legislation. This legislation also describes the inspection protocol for a limited number of items, but for most items there is no specific description on how to inspect them.
Consequently, inspection authorities need to develop procedures describing in detail how to perform the inspection. This is also one of the reasons why Belgian inspection authorities need to have an ISO 17020 accreditation so that inspection methods are traceable and transparent.
One of the items that must be inspected are spray rate controllers on sprayers.
Due to the increasing number of sprayers fitted with a rate controller ILVO felt the need to develop a new time saving and accurate inspection method for spray rate controllers.

Fig. 1. Inspection van with lift and test equipment (Flanders).

Belgian law : spray rate controllers inspection limits

The inspection of spray rate controllers is described as follows in the Belgian legislation:
"Mechanical and electronic regulation systems with a flow equal with the driving speed and the electronic indication from the sprayed volume per hectare are inspected (respectively D.P.A.m and D.P.A.e systems). The driving speed and the sprayed amount during a certain period are determined. The amount that is sprayed in reality is calculated and compared with the set values on the rate controller. When the difference between the amount that is sprayed in reality with the set value on the rate controller is more than 10% then the sprayer is rejected."
Hence, there is no description on how to inspect this item and as a consequence, inspection authorities need to set up an inspection protocol themselves.

Original inspection method for spray rate controllers (until 2009) .

To check application rate and sprayer speed, the following method was used till 2009:
Two marking points were placed with a distance of 100 m in between with at least 10 to 20 m of free "run in" track before the start of the 100 m track. Farmers/fruit-growers were asked to program their usual application rate and to start a first short run (e.g. about 20 m) at a constant speed. During this run, the rate controller could adjust the control valve to obtain the desired application rate. After this run in, the farmer was asked to stop spraying by shutting of the main valve and the inspector placed 3 spray test sacs underneath three nozzles (Fig. 2).

Fig. 2. Spraytest bags.

In a second run, the driver was asked to start driving again at constant speed and to open the main valve from the sprayer just after passing the first marking point and at the same moment the inspector started up the stopwatch. When finishing the 100 m track, spraying and stopwatch were stopped. The spraytest bags were removed and the contents of the bags were poured into a measuring cup with accurate scaling. The mean value was calculated and al the measured values were putted into the inspection software to calculate the actual spray rate and compare it with the value set in the spray rate controller.

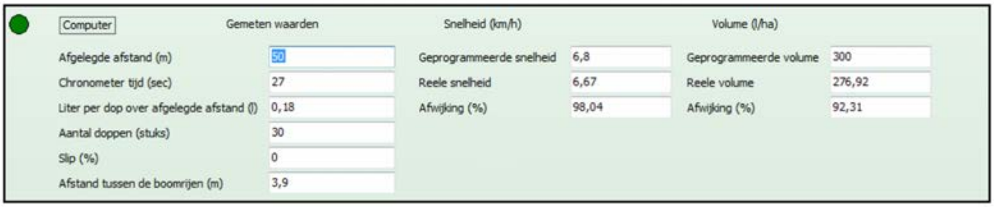

Fig. 3. Screen shot from the spray rate calculation program.

As one can see this method has a lot of disadvantages and also entails some inaccuracies. Firstly, when re-opening the main valve at the first marking point the rate controller shall have to (re)regulate some meters to obtain the desired rate. Further on the driver needs to start and stop spraying at the moment of passing the marking points and, at the same moment, he has to pay full attention on maintaining the desired speed. Finally, there is also the inaccuracy of the inspector to start-stop the stopwatch, and read out the measuring cup. To compensate those inaccuracies, a long test track is used (100m+20m). With a consequence that it is difficult to find a suitable location to perform this test.

New inspection method for spray rate controllers in Flanders (from 2010).

To overcome the problems involved with the original inspection method using the spraytest bags and the stopwatch, a new testing device was developed at ILVO. Main goal was to reduce the length of the test track and to decrease test time while maintaining or even improving accuracy. Furthermore the test device needed to be easy to use even for a "non professional".

To obtain these objectives, ILVO developed an accurate and reliable method where an "on the go" measurement was possible. In this way, the main inaccuracy caused by reopening of the main valve at first marking point and rate (re)regulation first meters of the test strip is eliminated.

The measuring device consists of a flowmeter attached between a nozzle holder on the sprayer and a pre-measured nozzle (Fig. 4). As already mentioned, in Belgium nozzle flow is measured separately on a nozzle test bench during the inspection so the average nozzle flow of a nozzle set is known. The pre-measured nozzle is selected as a nozzle with a flow rate close to the average flow rate. So measuring the flow through this nozzle in combination with a speed measurement, makes it possible to determine the spray volume rate in an accurate way. The starting and stopping of the measurement is still done manually for a track length of 25-50 m but the start/stop of the time measurement is coupled with the start/stop of the volume rate measurement and is performed by the inspector.

Some preliminary tests were done in 2008-2009 with different types of flowmeters and read- out units and two different prototypes were made. Finally in 2010 five final versions were made, three for daily use (three inspection teams) and two spares .

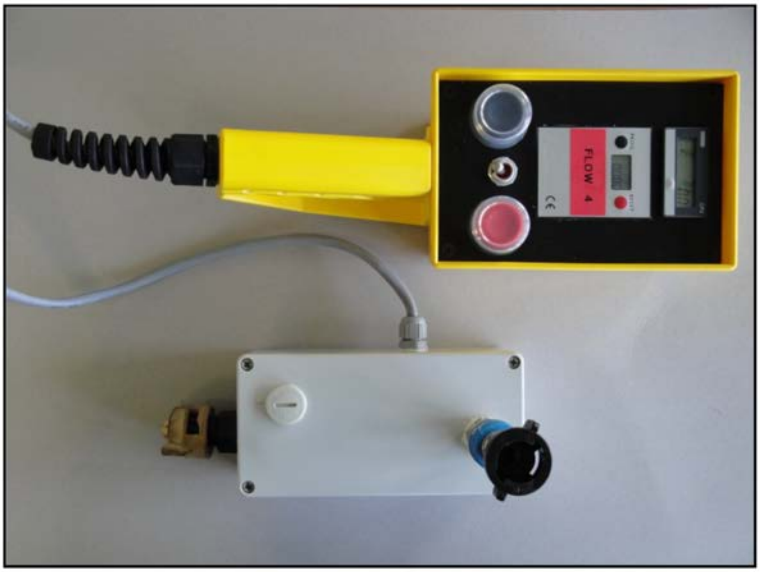

Fig. 4. Spray rate controller inspection eauipment.

As shown in Fig. 4 the testing equipment exists of a flowmeter that is built in into a polycarbonate housing with at the inlet of the flowmeter a universal festo adaptor and at the outlet of the flowmeter a standard TeeJet nozzle holder.

The flowmeter is wired to a spray rate/volume read out unit through a double pole toggle switch which can interrupt the pulses from the flowmeter and also commands the stopwatch. Stopwatch and read out unit are powered by a simple long lasting lithium-ion battery and are built into a watertight handheld unit. The wire between flowmeter and read out unit is about 10m long and watertight fixed to flowmeter housing and handheld unit. The flowmeter has a measuring range from 0.25 l/min to 5.5 l/min and is calibrated in the BELAC accredited Spray Tech Lab at a flowrate of 1.5 l/min with a calibration accuracy of at least +/- 0.5%. Accuracy at flows of minimum 0.75l/min and maximum 2l/min is still within a tolerance from +/- 1% (EN13790 asks +/- 1.5%).

Usage of the testing unit .

The test procedure consists of different steps:

1. At first two marking points are placed but instead of the 100 m that were placed with the original method, 50 m is sufficient and even distances of 25 m give satisfying results on condition that the “run in” of the test track is long enough to obtain a stable rate and speed.
2. The farmer/fruit-grower is asked to program a spray application rate that lies in the range of 0.75 l/min to 2l/min of the flowmeter (1.5 l/min nozzle flow rate is recommended).
3. The inspector mounts the flowmeter with the pre-measured nozzle on the spray boom and takes place in the tractor/sprayer cab with the handheld unit. The volume and the stopwatch on the handheld unit are set to zero and the farmer/fruit grower is asked to start spraying at a constant speed.
4. When passing the first marking point the measurement (stopwatch and volume) is started up “on the go” by switching on the toggle switch. During spraying the display can be changed between real time flow rate and total sprayed volume so a pre check is possible.
5. By passing the second marking point toggle switch is switched off and the farmer/fruit grower is asked to stop spraying.
6. Afterwards all measured and programmed values are putted into the inspection software and the real flow rate is calculated and compared with the desired flow rate.

Fig. 5. Testing in practice.

As one can see the complete inspection procedure has been shortened and the new method has a lot of advantages. The driver can completely concentrate on driving and maintaining a constant speed. There is also no need to stop and restart at the first marking point resulting in a more accurate measurement and saved time. Also important to mention is that while performing the test the real time flow rate can be read out so while driving the inspector can already determine if the spray rate controller works correct. Furthermore after testing, the volume can be read out directly with a known accuracy.
Moreover, the device can also be used to measure the real time nozzle flow rate of all nozzles on the sprayer, although originally it was not designed for this purpose.
However the equipment has some smaller disadvantages such as the limited measuring range due to the one point calibration (0.75l/min – 2l/min) and it also needs maintenance and validation on a regularly base.

Conclusions

After 2 years of daily use we can conclude that the testing equipment fulfils our needs and that the main goals are achieved. The test track is shortened and the procedure is less time consuming with the same or even a higher accuracy.

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Evening program

Low-loss spraying

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Summary

"Low-loss spraying" is a new application technique which has been developed by the Association of Styrian Commercial Fruit Growers (Austria), the Marktgemeinschaft Bodenseeobst (Germany) and the South Tyrolean Extension Service for Fruit- and Winegrowing (Italy) and is being put into practice at present.
These three fruit-growing regions, which use for the most part the same sprayer types, are faced with new challenges: larger areas per sprayer with higher trees, also in intensive orchards, than in the past (up to 4 m), stricter standards regarding drift reduction, power consumption and noise.
The pivotal element of this new application technique is an optimized and controlled air blast. The direction and intensity of the air stream are important factors for the coverage and the losses caused by spray drift. Therefore, the professional school for fruit-growing at Gleisdorf (Austria) constructed an air-flow test bench, which served as a model for three new test stands, which were bought by the Marktgemeinschaft Bodenseeobst, the South Tyrolean Extension Service and the manufacturer of spraying equipment Lochmann.
In addition to the usual legal requirements, "low-loss" sprayers have to be equipped with a fan producing an appropriate vertical distribution of the air, drift-reducing flat jet injector nozzles at the top and hollow-cone nozzles below them as well as standardized test ports for the pump and pressure gauge.
It is indispensable for the grower to have access to appropriate training and counselling in order to be able to adjust his sprayer in an optimal way to the shape of his trees with regard to air flow, water and pesticide amount, pressure, forward speed and rotation speed of the PTO.

Introduction

The application of pesticides in bush and tree crops, such as in fruit- and winegrowing, usually causes more drift than in arable farming. Whereas in the past the focus was mainly on the biological effect, now and even more in the future the aspect of drifting has to be taken into consideration.
One way of reducing drift and improving the biological efficacy of a pesticide is "low-loss spraying".

Legal requirements regarding drift

The South Tyrolean fruit- and winegrowers have to comply with several legal requirements regarding drift:

- The EU-Directive on the sustainable use of pesticides;
- the provincial guidelines on the distances to be kept when treating orchards bordering on residential or public buildings as well as roads and other properties which are not agriculturally used;
- the use instructions on the labels regarding the distances to waterways.

A sensitive topic is the application of pesticides next to villages and tourist areas. Concerned citizens turn to the local authorities and the media, which do not always deal with this topic in a rational way and often stoke people's fears. "Low-loss spraying" diminishes the drift and the visible spray plume considerably. This application technique requires a cross-flow fan, air induction nozzles, optimum air distribution and an amount of air adjusted to the tree height in the respective orchard.

Taller trees – not easy to achieve good coverage

For the past fifteen years the apple trees in South Tyrol have not been trained any more as a 2 – 2.5m high "slender spindle" according to the Dutch model but as a "tall slender spindle". Geometrically, the shape of the "tall slender spindle" resembles more or less a column. Thus, it has become more difficult to achieve good coverage in the 3.5 – 4m high tree tops. As can be seen from the inspection protocol, when using sprayers without cross-flow fans too much liquid is applied to the lower part of the tree and too little to the top section.

"Low loss spraying"- 4 key factors

"Low loss spraying" is a joint project of the Styrian Commercial Apple Growers (Austria), the Marktgemeinschaft Bodensee (Germany) and the South Tyrolean Extension Service for Fruit- and Winegrowing (Italy). Common guidelines have been drawn up and can be seen on the homepage www.obstbau.at.

Key factor 1 – Even air distribution

The first important condition for "low-loss spraying" is a uniform air-distribution from top to bottom of the target trees. This can be measured and, if necessary, optimized at an air testing facility which checks air speed, the amount of air and the direction of the air flow.

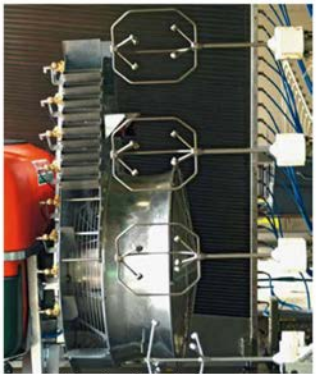


Fig. 1. Device for air flow measurements.

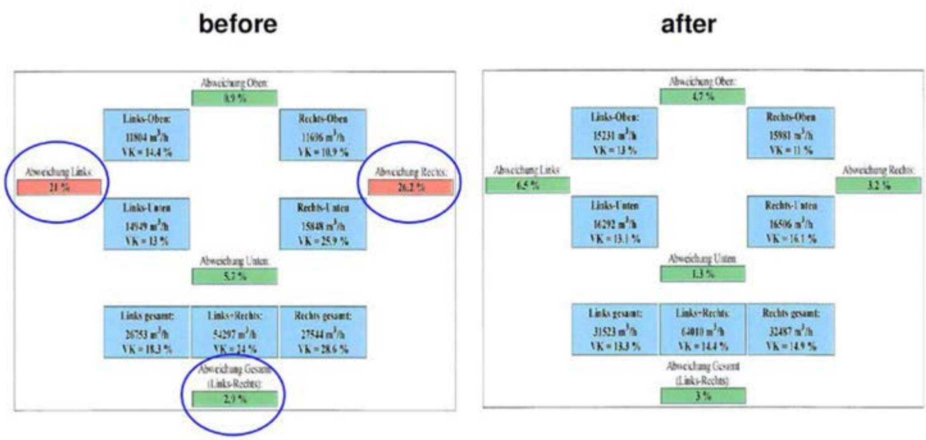
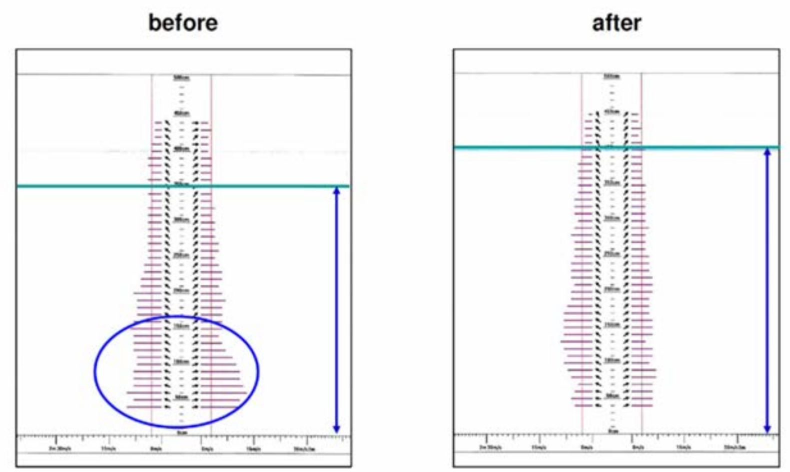


Fig. 2. Air flow test protocol.

At the air testing facility the amount of air ejected is measured up to a height of 5m. It is divided into 4 areas and represented in a quadrant comparison chart. The amount of air on the left is compared with that on the right, and the amount in the lower half is compared with that in the upper half. If the difference does not exceed 10%, a green box appears in the test protocol.
The two red boxes indicate that the air amount in the bottom half is on both sides higher by 21%, respectively 26% than in the upper half. Since the nozzles in the upper half transport the droplets to the top of the trees, the air blast is too strong for the lower part and too weak for the upper part of the trees. After calibrating the sprayer and mounting air deflector plates an even distribution over the whole height of the target trees was achieved.
At the air testing facility air speed and direction are also measured and shown in the form of a diagram. The air speed is measured at 10cm-intervals and depicted as a vertical bar. The longer the bar, the higher is the speed. The test protocol on the left shows that air velocity is too high up to 1.5m from the ground. The two vertical lines mark a minimum speed of 3m/second. We assume that this minimum velocity has to be reached at the test stand in order to be certain that sufficient liquid is deposited on the trees in the orchards. The tested sprayer reached this speed up to a height of 3.5m. Before the adjustment the air speed was therefore too high in the lower part and sufficient up to only 3.5m. By in-

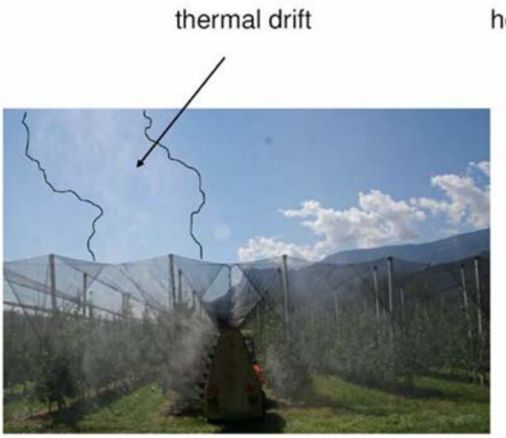


stalling and adjusting air deflector plates a more uniform air distribution up to 4m was achieved.
Fig. 3. Air speed diagram.

Key factor 2 – Use of different nozzle types

"Low-loss spraying" also requires a mixed set of nozzles. On the lower part hollow-cone nozzles are mounted, the last three nozzles at the top are air induction nozzles.
In our orchards and vineyards drifting and spray plumes are caused primarily by the uppermost nozzles. In both pictures the right hand side of the sprayer is fitted with hollow-cone nozzles and air induction nozzles, the left hand side only with hollow-cone nozzles. Thermal drifting occurs on sunny days with updraughts. The smallest and therefore lightest droplets rise and can travel as far as 100m.
By mixing nozzle types we are trying to balance the advantages and disadvantages of both hollow-cone and air induction nozzles.
The lower part of the tree is sprayed with hollow-cone nozzles. Since they produce smaller droplets, the coverage rate is better and losses due to runoff are lower than with air induction nozzles, which eject larger droplets. Due to an improved air flow drifting is negligible in the lower part of the tree.

The upper part of the trees, on the other hand, is sprayed with air induction nozzles. The disadvantage of a poorer coverage rate is balanced by a sufficiently strong air blast towards the upper area of the canopy. The larger droplets emitted by air induction nozzles are carried less far and fall on the canopy or the orchard floor. Furthermore, in this way a conspicuous spray plume which can be seen



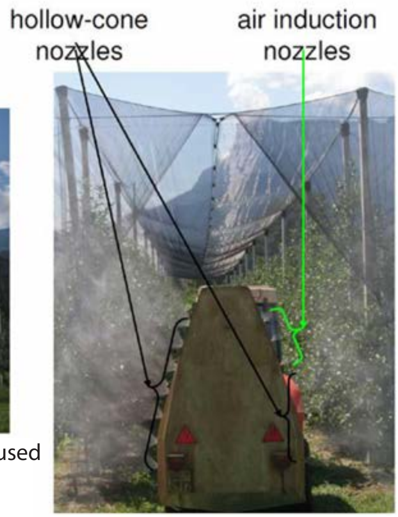
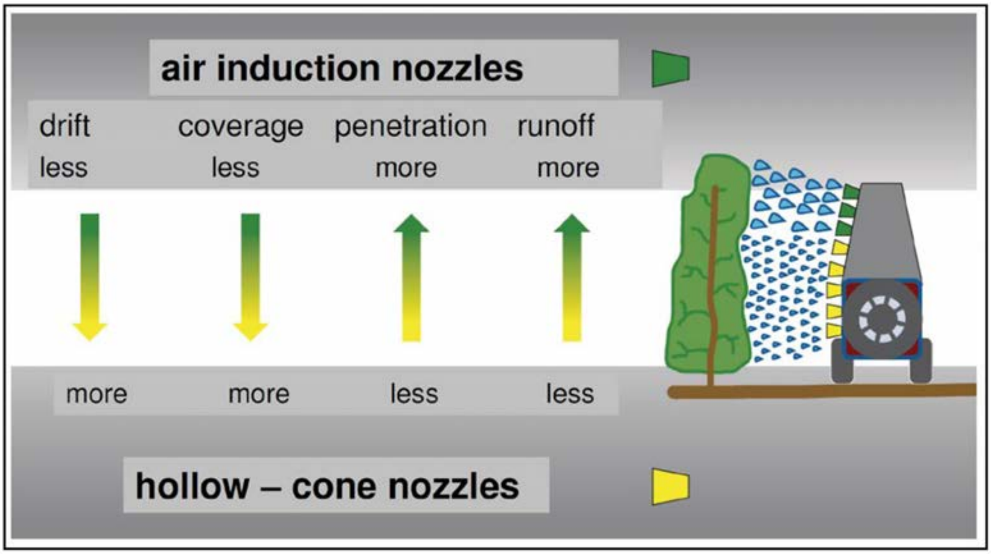


Fig. 4. In orchards drifting and spray plumes are caused primarily by the uppermost nozzles.



from afar can be avoided.

Fig. 5. Pros and cons of different nozzle types.

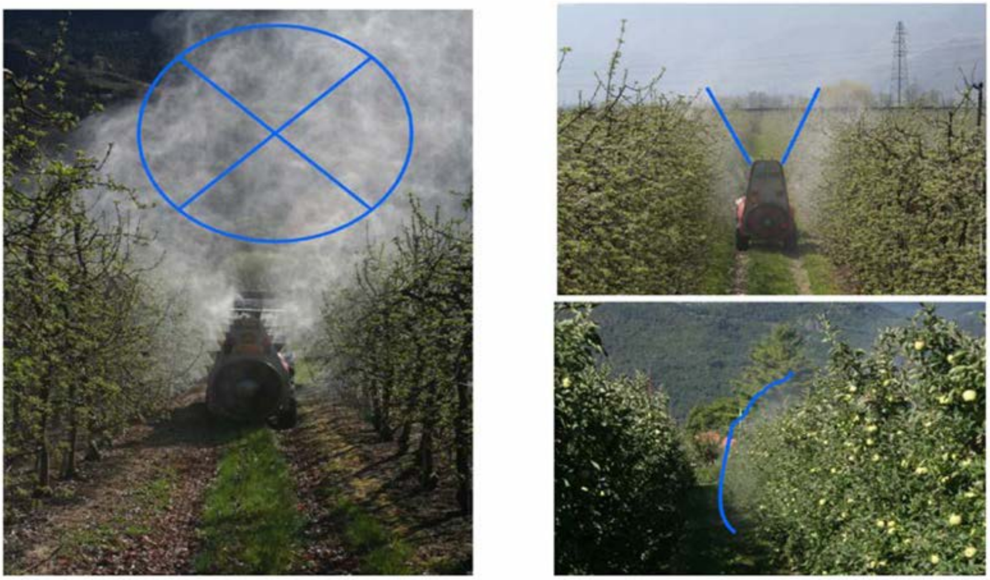
Key factor 3 – Good filter system

Since air induction nozzles are prone to blockage, a good filter system is indispensable for ensuring that they will work smoothly.

Key factor 4 – Adaptation to the individual orchards

The fourth condition for "low-loss spraying" is determining the exact quantity of pesticide and liquid necessary as well as the air pressure and driving speed required for an efficient treatment of the individual orchards.

The South Tyrolean Extension Service offers assistance to each of its members in working out a chart listing the exact liquid amount per hectare as well as the necessary pressure and driving speed. The Marktgemeinschaft Bodensee and the Association of the Styrian Commercial Fruit Growers calculate



this using the "Mabo Dosage Model".
Fig. 6. Adaptation of the air blast to the individual orchards.

Even a tested and optimally calibrated sprayer can serve its purpose only if it is correctly used by the grower. Therefore, the sprayer has to be adjusted to the individual orchards after the air flow tests. The spray plume has to be optically assessed by a second person while the sprayer is being driven through the orchard. Only in this way is it possible to ideally synchronize the driving and rotation speed needed to ensure that the droplets reach the tree top while at the same time penetrating the canopy only gently. No visible spray mist should reach the neighbouring tree rows.
In order to be calibrated at the testing facility, the sprayer has to be equipped with connections for the manometer and the pump test.

Conclusions

The "low-loss spraying" effort shall enable the grower to buy a sprayer ideally adjusted to the height of his trees, allowing him to apply a pesticide in such a way that it gently penetrates the canopy without drifting into the next alley or in the air above the tree tops. With the "low-loss" sprayers in use at present power consumption and the noise of the fan have been reduced on average by half, as demonstrated by measurements performed by the Bundesanstalt für Landtechnik Wieselburg (Austria).
The manufacturers of "low-loss" sprayers are therefore challenged to construct fans with uniform air distribution up to the necessary tree height and an exact limitation there.
If the sprayer meets all the requirements for "low-loss spraying", an inspection label is attached to it. You will find further information about this application technique on www.obstbau.at.

Low-Loss-Spray-Application - The Scientific Basis

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Summary
Limited time frames caused by infection threat and weather demand for efficient pesticide application techniques in modern integrated and organic fruit farming. This demand is best complied by low volume spraying, since it minimizes traveling time and number of fillings per spray treatment, but also minimizes the probability of a contamination of the operator with concentrated pesticides. To obtain good spray deposition, low volume spray application demands small droplets which offer numerous benefits, but also carry a high drift potential. This feature threatened the technique, because no method for spray drift reduction has been available in order to make use of reduced buffer zones to water courses and non-target areas. A new method based on cross flow characteristics of the sprayer fan, canopy adapted forward speed and fan speed and a mixed set of hollow cone nozzles and air induction nozzles resulted in an approx. 85% reduction of particle drift deposits, so that the method has been registered in the official German list of drift reducing devices in the 75% drift reduction class. Besides drift reduction a canopy adapted fan speed also results in an enormous reduction of fuel consumption and noise emission as further environmental benefits of small droplets. An assessment of the influence of a canopy adapted forward speed and fan speed on spray deposit, relative spray coverage and droplet deposit density revealed a significant increase of the application efficiency, rising with decreasing canopy width and compensating a reduction of water volume and dose rate from canopy related dosing models. Testing a tower sprayer in orchards for use with reduced fan speed unexpectedly showed an unusable vertical air distribution. Alarmed by this finding, a subsequent testing of various fan types on a test bench disclosed a very unsatisfying vertical air distribution of many fan types and even within a production series the air distribution differed enormously. Especially an uneven horizontal reach of the air stream over working height is a major obstacle for a successful use of canopy adapted fan speed with all its benefits. Since a uniform vertical air distribution is the basic requirement for a highly efficient and environmentally safer spray application not only in terms of the potential to reduce pesticide consumption, but also for reducing fuel consumption and noise emissions, testing and adjusting fans of orchard sprayers on a test bench is urgently needed. Because of the importance of the topic, three fruit growers associations in Austria, Italy and Germany together initiated the development of a new test bench to measure vertical air distribution of orchard sprayers.

Introduction
In modern crop protection in integrated and organic top fruit growing with a few exceptions only protectant fungicides are used against apple scab (*Venturia inaequalis, Cke., Wint.*). These fungicides have to be applied as close as possible before a rain event to minimize leaf growth between the application and the rain event, which is crucial to maximize residual activity for covering as many infection periods as possible. Right before the onset of a rain event weather conditions with low natural wind are an additional factor which may limit the time window available for optimal fungicide application. In important European fruit growing regions very often the blocks are rather small and are spread within the vicinity of a fruit farm requiring a lot of extra time for traveling between the orchards and for sprayer filling. This may consume significant time in relation to the total time required for a fungicide treatment of all blocks of a fruit farm. As a last factor the number of fillings per spray round has to be minimized in order to minimize the chances of contamination of the operator with the concentrated pesticides.

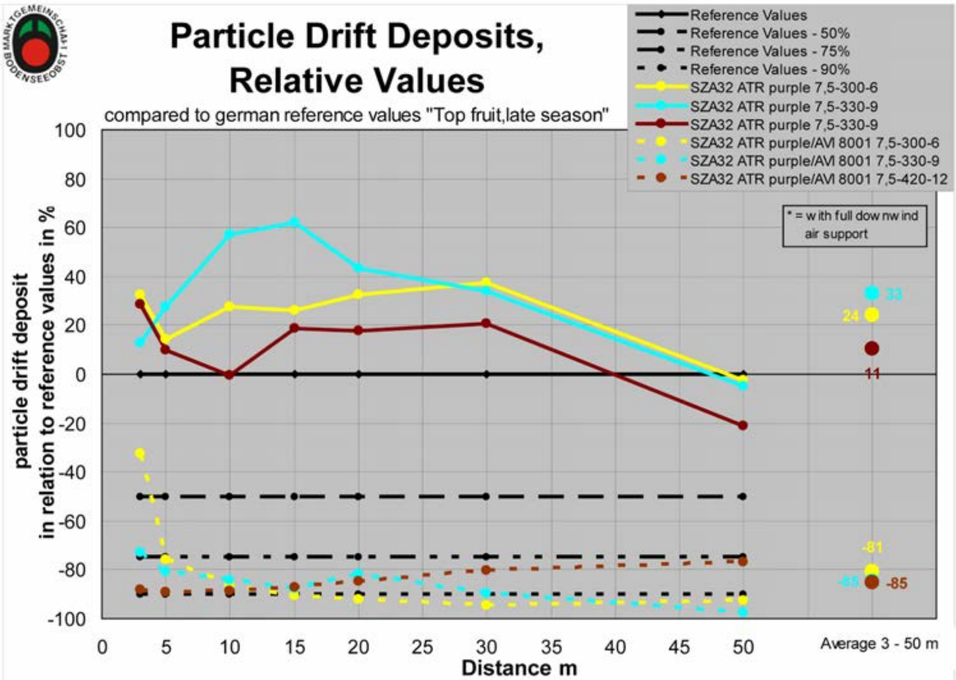
To maximize work rate under these constraints, low volume spray application with small droplet hollow cone nozzles (e.g. "Albuz ATR purple") has become standard in the late 1980ies in large fruit growing regions in the UK, The Netherlands, Austria and Germany. Further reasons to use small droplets have been low risks for visual spray deposits on the fruit and phytotoxicity, and a potential to reduce pesticide dose rates. Some innovative growers using tower sprayers with small droplet spay application since many years also adapted the fan speed to the canopy because this already visually seemed

to keep a higher amount of the spray mist in the canopy, assuming that it might improve spray deposition and reduce spray drift. These growers also reported a significant reduction of fuel consumption and noise emissions from a reduced fan speed.
With the appearance of large droplet nozzles in order to reduce particle drift deposits as a basic requirement to legally reduce buffer zones to water courses for the application of pesticides, low volume spray application was endangered to be no more applicable for efficient crop protection. Therefore an alternative method for spray drift reduction that maintains the enormous benefits of low volume spraying technique with small droplets had to be developed, combining the needs of growers with official demands to minimize particle drift deposits.

Spray drift reduction with small droplet nozzles

Since spray drift trials with small droplets are rare, it has been necessary to check the status quo of spray drift from small droplet nozzles. From this starting point new drift reducing methods should have been developed for its reduction. The aim was a particle drift reduction that allowed a registration at least in the 75% - drift reduction class of the official German list of spray drift reducing devices of the JKI at Braunschweig. The basic idea to achieve this reduction was an adaptation of the reach of the air stream from fans with cross flow characteristics to the canopy so that only very little spray mist passes the canopy, moving into the next alley way and being released into the atmosphere above the canopy.
A trial, based on the official German protocol for particle drift deposit trials was carried out to assess the effect of a cross flow fan and reduced fan speed at various forward speeds in combination with the hollow cone nozzle "Albuz ATR purple" on particle drift deposit.
A "Wanner N36-A" axial fan was used as a reference to test the effects of three combinations of fan speeds and forward speeds to compare with the "Wanner SZA32" axial fan with cross flow characteristics, where the downwind facing air outlet was not closed by the deflector plate. In a first treatment at a forward speed of 6 km h^{1} the effect of replacing the axial fan by an axial fan with cross flow characteristics at identical settings of forward speed and fan speed was evaluated. Further treatments were carried out at a forward speed of 6 km h^{1} while reducing fan speed to 420 min^{1} and finally to the canopy related value of 300 min^{1}. The tests have been repeated with further combinations of forward speeds and canopy adapted fan speeds (9 km h^{1} at 330 min^{1} and 12 km h^{1} at 420 min^{1}).
Compared to the German reference values, the axial fan produced an average particle drift deposit 4,1-fold above the German reference value "top fruit; late season". The axial fan with cross flow characteristics with every other settings remaining unchanged yielded a value 2.4-fold higher than the reference, reducing particle drift deposits by 42% compared to the axial fan. Reducing fan speed to 420 min^{1} of the cross flow fan resulted in a value 1.5 fold above the reference analogical an extra 36% reduction from the previous value. The canopy adapted PTO speed of 300 min^{1} finally resulted in a particle drift deposit 24% above the reference values. This complies to a 94% reduction compared to the axial fan at nominal PTO speed (540 min^{1}).

Since forward speeds of 9 and 12 km h^{1} produced particle drift deposits of 33% and 11% above the reference value, it may be concluded that tower sprayers with a full set of the hollow cone nozzle "Albuz ATR purple" at canopy adapted fan speed produces approximately the same spray drift at any forward speed between 6 and 12 km h^{1}. Replacing the three topmost hollow cone nozzles with two air induction nozzles "Albuz AVI 8001" and operating the tower sprayer with the same settings as before, reduced particle drift deposits between 81% and 85% below the reference value (**graph 1**). These results allowed the listing of those sprayers in the 75% drift reduction class of the official German list of drift reducing devices.Repeating the trials with the mixed nozzle set and the same canopy related settings of forward speed and fan speed under hail net, raised particle spray drift reduction to values between 95% and 96% so that the system of a fan with cross flow characteristics, canopy adapted dosing and spray application in combination with a hail net may be listed in the 90% drift reduction class.



Graph 1. Particle drift deposits in relation to reference values "top fruit - late season" from an tower sprayer with canopy adapted fan speed at 6,0, 9,0 and 12,0 km h-1. Upper graphs: 16 x hollow cone nozzle "Albuz ATR purple"; lower graphs: mixed nozzle set of 12 x hollow cone nozzle "Albuz ATR purple" and 2 x AVI 8001.

The effects of a canopy adapted fan speed on spray cover

With the possibility of reducing particle drift deposit by at least 75% without any constructive modifications of the sprayer fan, it was interesting to assess the influence of a canopy adapted spray application on spray cover parameters as there are spray deposit, relative coverage and droplet deposit density. A "Wanner SZA32" tower sprayer, fitted with 2 x 8 hollow cone nozzles "Albuz ATR purple" has been used for the trial work. Spray deposit has been analyzed fluorometrically while image analysis has been used to assess relative coverage and droplet deposit density, each separately on the upper and lower leaf surface. For covering the range of canopy structures in modern commercial fruit farms, a three row bed, a slender spindle and a super spindle orchard has been chosen where the classical method of spray application (constant water volume, relatively low forward speed at nominal fan speed) has been compared with the results of the MABO dosing model (canopy adapted values of water volume, forward speed and fan speed) (**tab.** 1).

Tab. 1. Treatments for assessing spray cover on apple leaves

Treatment	Canopy system	Method of dosing and application	Spray liquid pressure bar	Water volume l ha^{1}	PTO-speed* min^{1}	Forward speed km h^{1}
I	3-row-bed	„grower“	16.5	200	540	6.7
II	3-row-bed	„model“	7.5	237	460	3.8
III	Slender spindle	„grower“	9.0	200	540	8.0
IV	Slender spindle	“model”	7.5	153	330	9.0
V	Super spindle	„grower“	11.0	200	540	9.0
VI	Super spindle	„ model“	7.5	114	290	12.1

Operating a tower sprayer with an almost horizontal air stream equipped with small droplet hollow cone nozzles with canopy adapted forward speed and fan speed, resulted in a general increase of the application efficiency in all three canopy structures, increasing as canopy width decreased. For the spray deposit on the entire leaf area, this increase in efficiency (calculated as µg cm^{2} l^{1}) ranges from 14% in the bed system, 29% in the slender spindle to 35% in the super spindle orchard. Specific relative coverage (% l^{1}) on the upper leaf surface revealed a decrease of 29% in efficiency in the bed system, but an increase of 26% in the spindle and 67% in the super spindle orchard. Assessing droplet deposit density on the upper leaf surface, disclosed an increase of application efficiency (n l^{1}) beginning with a slight decrease of 5% in the bed system, increasing from 27% in the spindle and 55% in the super spindle canopy (**tab.** 2).

Tab. 2. Changes in average efficiency of spray deposition of "model" in relation to "grower" in three different canopy systems

	3-row bed	Slender spindle	Super spindle
Spray deposit (entire leaf)	14%	29%	35%
Relative coverage (upper leaf surface)	-29%	26%	67%
Relative coverage (lower leaf surface)	-27%	-3%	7%
Droplet deposit density (upper leaf surface)	-5%	27%	55%
Droplet deposit density (lower leaf surface)	17%	28%	27%

The results clearly show that canopy adapted spray application using fans with cross flow characteristics does not only reduce particle drift deposits when fitted with small droplet nozzles, but also increases spray deposition efficiency significantly on the upper leaf surface, when compared to classical spray application with relatively low forward speed and nominal fan speed. This increasing efficiency in the "model" treatment completely compensated a reduction of water volume and pesticide dose rate of 25% in the slender spindle and a reduction of 43% in the super spindle to an extent of 77%.

On the lower leaf surface, average values of relative coverage and droplet deposit density have been approximately 2.5-fold higher compared to the upper leaf surface for the "grower" settings, while values obtained from "model" settings have been 2-fold higher. From these results may be concluded that also spray deposit is significantly higher on the lower leaf surface compared to the upper one, although a tower sprayer has been used.

The adaptation of the air stream to the canopy structure by fan speed and forward speed in most cases also reduced the gradients between the surface and the center of the canopy, thus leading to a more uniform spray deposition over canopy width. Coefficients of variation calculated from the 120 samples per treatment also did not disclose any remarkable difference compared to the "grower" settings. Another positive effect obtained from canopy adapted forward speed and fan speed was a better spray deposition on the upper leaf surface in the upper part of the canopy in the center of broad canopy systems which may reduce pest and disease infestation, frequently occurring under classical application with high fan speed and relatively high forward speed. Finally a canopy adapted fan speed leads to an enormous reduction of fuel consumption and noise emissions, reducing the CO_2-footprint of fruit production as well as preventing complaints from settlements in the vicinity of orchards.

With these results, providing a method of spray drift reduction for small droplets easily applied in practice without quantitative and qualitative compromises in terms of spray deposition, a method to preserve low volume spray application for growers as a highly efficient spray application technique has been found. As positive side effects it adds reduced pesticide consumption from canopy adapted dosing and significant reduction of fuel consumption and noise emission to the list of benefits of small droplets.

Vertical air distribution - the unexpected obstacle

As prerequisites for registering tower sprayers in the official German list of spray drift reducing devices for this method of spray drift reduction in the 75% spray drift reduction class, the Julius-Kühn-Institute (JKI) at Braunschweig, Germany, demands that the sprayer has to be a cross flow fan sprayer or a tower sprayer with cross flow characteristics equipped with a full set of air induction nozzles, already registered in the 90% drift reducing class. Equipped with the mixed nozzle set the sprayer has to be operated according the results of the MABO-dosing model concerning water volume, pesticide dose rate and forward speed at canopy adapted fan speed. As references, the PTO speed has to be determined that is required to just penetrate the canopy of orchards in full leaf, where the MABO-dosing model computed forward speeds of 6, 9, and 12 km h^1.

Testing one of the first tower sprayers with cross flow characteristics suitable for this method of spray drift reduction in an orchard, even without reducing fan speed disclosed a serious malfunction of the fan: since no redirecting system was installed behind the fan the tower was supplied only with the air from an approximately 940 cm^2 outlet area, corresponding to ca. 30% of the fan outlet, which after redirection by deflector plates then had to be distributed by the tower with a total outlet area of ca. 2840 cm^2, respectively an approximately 3-fold larger outlet area compared to the section of the fan supplying it with air. As a result the radial air distribution of the axial fan on both sides was cut off at an angle of approximately 45° symbolized by the red line in **fig.** 2. Therefore on one hand the air stream directly from the fan was creating a barrier for the weak air stream of the tower reaching the canopy while on the other hand the vertical angle of the direct air stream of the fan was too low to reach the top of the trees, leaving them partly untreated. At the tower the air stream was decreasing with increasing sampling position and at the top of the tower the air support was so low that the spray mist from the top most nozzle did not even move away from the tower but partly deposited at the rear side of the tower and also formed a vertical cloud of droplets drifting vertically into the atmosphere (area framed by the blue line). This observation has been confirmed by growers reporting serious apple scab infestation at the top of the trees after having purchased this sprayer type. Alarmed by this situation, a whole range of orchard sprayers with cross flow characteristics has been tested with the air test bench borrowed from the fruit growing school at Gleisdorf, Austria. The results disclosed that with a few exceptions the fans with cross flow characteristics showed a defective air distribution, ranging from a generally too low working height to big differences between the two fan sides. In some cases a satisfying function in top fruit production even at full fan speed has been questionable. But also vertical air distribution very often was strongly uneven, making it impossible to adapt fan speed to the canopy for efficient spray application because then the air stream that was already weak at one or more sections of the fan at full fan speed would have been too low to generate sufficient spray cover at the canopy sections being treated by this section of the fan. A selection of vertical air distributions is presented in **fig.** 3, where the horizontal lines picture the maximal air speed and the small arrows in the center of each graph indicate the direction of the air stream at each measuring position.

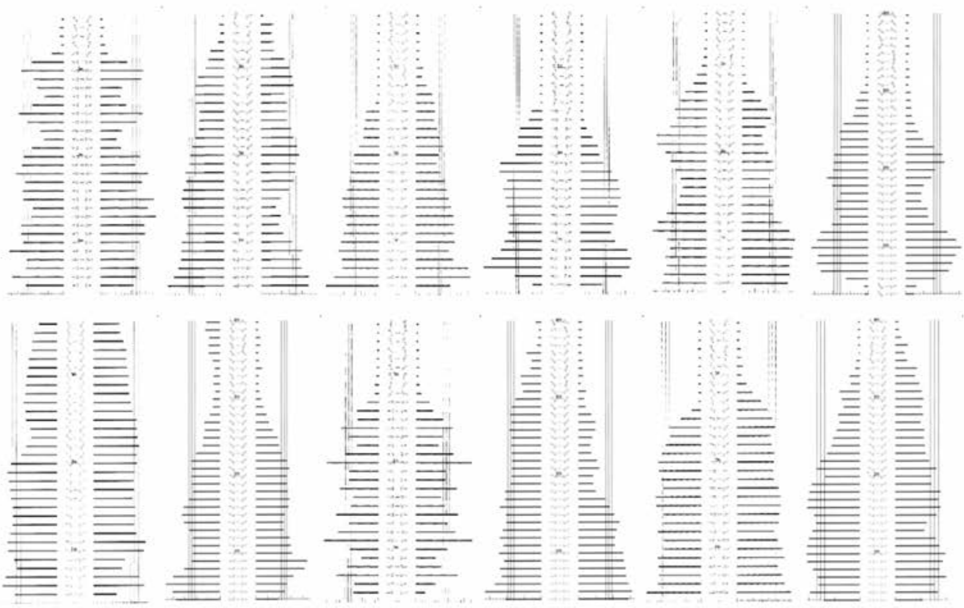


Fig. 3. Examples of the vertical air distribution of various types of fans of orchard sprayers with cross flow characteristics.

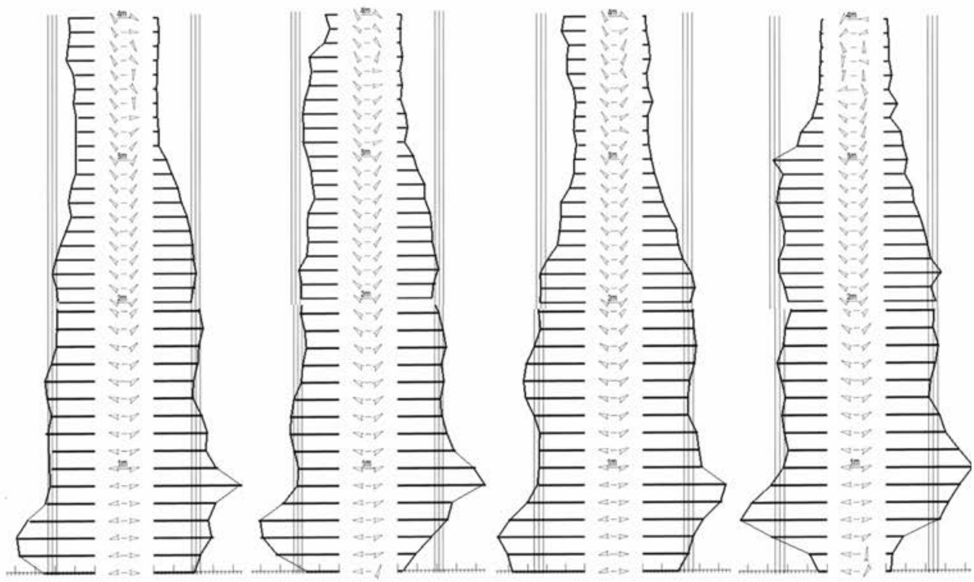


Fig. 4. One example of the varying vertical air distribution of individual fans from a series (axial fan with cross flow characteristics) for the treatment of tall trees (e.g. stone fruit).

Measuring several fans from one fan series in addition showed that the vertical air distribution was not uniform as to be expected, but showed big individual differences (**fig.** 4), very likely originating from tower assembly.
As a general picture from many fans tested, vertical air distribution in many cases has been very poor in terms of uniformity of working height, uniform angles of the air stream at both sides of the fan and uniform reach of the air stream over the working height. In addition individual fans from a series showed no uniform pattern of air distribution, but may vary remarkably from machine to machine. From these findings may be concluded, that testing and possibly also adjusting the vertical air distribution of every new orchard sprayer before purchase is an essential need when aiming at a highly efficient spray application, especially with small droplets and low volumes, producing high quality spray cover on the target, reducing spray drift compared to air induction nozzles, reducing pesticide consumption technically as well as fuel consumption and noise emissions.

Conclusions

Tab. 3. Basic features of the new air distribution test bench "WP 5000"

Dimensions (folded)	3,85 m, 1,30 m, 1,50 m (l, w, h)		Before/after modifications; 3 pages:
Weight	485 kg		summary; wind speed and direction:
Measuring principle	Ultrasonic (0 - 60 m s^{-1})	Protocol	vX; IvI; vXZ; quadrants comparison;
Number of sensors	5		for each fan type: specific energy
Recorded data	Wind speed m s^{-1}, x-, y-, z-direction		consumption, CO_2-balance, noise
Effective range	2,0 m (h) x 5,0 m (v)		emissions (dBA)
Measuring grid	0,1 m (h) x 0,1 m (v)		Scan function, various protocols,
Records per position	Variable; default = 25		automatic evaluation of the air
Data transmission	WLAN	Special features	distribution according the „Low Loss
Time per measurement	< 25 min per fan side		Spraying" guidelines

Driven by these very unexpected findings, the "South Tyrolean Advisory Service for Fruit and W Growing" at Lana, South Tyrol, Italy, the "Styrean Fruit Growers Association" at Graz, Austria and the fruit cooperative "Marktgemeinschaft Bodenseeobst eG" at Friedrichshafen, Germany, representing a total fruit growing area of approximately 30.000 ha, in 2010 started a joint project for testing and adjusting the air distribution of new orchard sprayers as a first step to offer optimized orchard sprayers to the fruit growing industry in their regions. The reasons were to reduce negative environmental effects as there is spray drift from low volume spraying with small droplets, improve air distribution to allow operation with reduced fan speed for better and more efficient spray deposition, to bring down fuel consumption and noise emissions and to enable a reduction of pesticide consumption through canopy adapted dosing and spray application. Based on the experiences from the test bench that has been developed by the fruit growing school at Gleisdorf, Austria, in 1994, they assigned "Ernst Herbst Prüftechnik e. K." at Hirschbach, Germany, in 2010 with the development of a new test bench for measuring the vertical air distribution (fig. 5) of which some basic features are listed in tab. 3.

Completed by the mandatory sprayer testing extended by measuring the vertical spray liquid distribution with a patternator as the second step of testing and adjusting new orchard sprayers and the ones in use, the three organisations mentioned above develop and introduce a highly efficient but also environmentally safer spray application technique. The improvement and adjustment of air and spray liquid distribution of orchard sprayers is recognized as an important contribution to further implement their fruit industries business philosophies of an environmentally safer fruit production.

Fig. 5. The new air distribution test bench "WP 5000" (Photo: Triloff, 2012).

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Towards integration of inspection procedures, calibration and drift reducing devices for an efficient use of pesticides and reduction of application impact

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Summary

The fruit production of Trentino is an important industry of the local economy with a gross marketable production of about 215 million Euros with almost 75% comes by apples.

The characteristics of the cultivation environments allow to get quality products. This is made possible by the constant technical updating operated by technical support of Consulting & Services Centre – CTT. This is one of reasons why IPM has come in the practice since the early 90's and on this view the inspection of sprayers is mandatory and regularly made with five years interval.

Many housing districts are scattered among orchards and population of rural surroundings has become more and more sensitive to issues about environmental sustainability and spray drift. Therefore vertical bench tests started to follow the standard procedures of inspection and calibration to carry the operators to a more efficient way of application reducing drift losses.

Moreover in the last years has become needful to start a series of test in order to find technical solutions for drift mitigation. In our view the next step to allow an adequate and efficient use of drift reducing devices, and bring them in the practice, is to link inspection and calibration with drift reduction experiences. Informations, suggestions and adjustments are achievable by the technical staff of the inspection facilities (e.g. choice of a proper filter mesh size according with the nozzle type, etc.) during inspection activity. On this view training during inspection has a key role to make the operator conscious of the most appropriate technical choices for efficient use of pesticide application equipments.

Introduction

The fruit production of Trentino is an important industry of the local economy with a gross marketable production of about 215 million euros with almost 75% comes by apples. The characteristics of the cultivation environments allow to get quality products. To further enhance the quality of these productions, since the early 90's IPM has come in the practice. On this view the Association of Fruit and Vegetable Producers in Trentino (APOT), in co-operation with the Province Government and Technical Support Team of Edmund Mach Foundation, decided to get in practice the mandatory inspection of sprayers which regularly made with five years interval for all its associates.

In fact the main problem related with the quality of treatment was an unsatisfactory level of effectiveness on the top of plants. This has been attributed to the inadequate amount of deposit produced in the upper leaves and fruits during treatments due to the inefficiency of equipments used by the fruit growers. Deposition on canopy profile must be as homogeneous as possible according with the shape of trees to achieve good efficacy and in this way it was also necessary to place beside a calibration activity immediately after inspection.

Patternator calibration service provided by the mobile workshops in Trentino (bench calibration)

Calibration is necessary for spraying to ensure targetted, optimal use of PPP, minimize risk to the crop, consumer and environment and to avoid excess spray liquid at the end of the spray job (Andersen & Jørgensen, 2009). This important operation has long been an integral part of the inspection service in Trentino.

Once the sprayer has passed the inspection, on the basis of information provided by the user of the equipment, the technical staff of the inspection center fills out an information sheet containing the types of crops in the farm, the characteristics of trees and planting systems (distance between the rows and average height of the plants) and the specific working parameters employed (e.g. number of working nozzles, forward speed, PTO speed, concentration of the spray liquid).

Then a verification of the profile of distribution is carried out to the vertical patternator. When the symmetry between the left and right of the diagram is not sufficient or when the amount of liquid collected in the top of the bench is low the operator performs an correction of nozzle position by changing the inclination of the jet or when possible by moving nozzles on the boom. Through these operations is intended to improve the homogeneity of deposition profile on the foliage considering the crop characteristics.
At the end of the procedure two more records are released containing the optimal working parameters to be used for each of the cultivated species by the farm and the results of the vertical bench test, before and after the adjustment operations.
Where the equipment is partially or fully fitted with air injection anti-drift nozzles, the user may ask for the bench calibration is also done with such type of jets. Moreover informations and suggestions are achievable by the technical staff of the inspection facilities (e.g. choice of a proper filter mesh size according with the nozzle type, etc.) during inspection and calibration activity.

Adjustment of equipments on the canopy characteristics: past experiences and future perspectives

Apple growing in Trentino is characterized by such a number of varieties, methods of cultivation, planting distances and attitude of plots as to put it among the most elaborate and complex cultivated areas. This situation often requires the same grower to operate in very different contexts, both for planting density and size of vegetation (Fig. 1). That means, for the operator, difficulty in identifying the proper spray volume and doses of agrochemical depending on the operational situation.
With the aim to adjust the dose of plant protection product together with the appropriate spray volume considering orchard development characteristics (Crop Adapted Spraying), since 2004 a pluriannual series of experimental trials has been carried out in Trentino. Current results allow to make out useful parameters to apply the Tree Row Volume model (TRV). Infact the recent renewal of old (tall) plantings with modern orchards, consisting of smaller trees, require a new approach on application. The reference crop volume for the investigated orchard scenery is 12,000 m^3, which corresponds to a label-recommended dose for 1,500 l/ha of spray volume (standard volume) (Ioriatti et *al*., 2009; Bondesan et *al*., 2010).

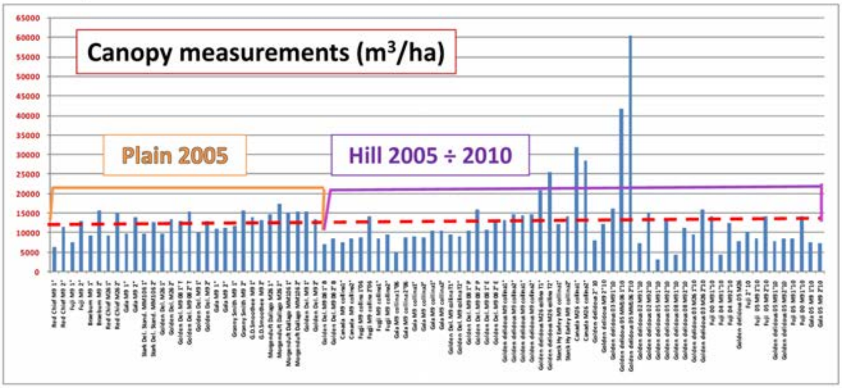

Fig. 2. Example of TRV-index evolution in plain and hill environments of Trentino: early (1) and full season (2) stage.

The most recent activity was intended to introduce in the practice of various farms the Tree Row Volume model which allows to calculate the amount of pesticide and the optimal spray volume for the existing vegetation so the farmer can obtain the quantities of pesticide to be applied in each of its plantings to avoid overdosing and adopting a more rational treatment. During the season2011, as done in 2010, the farms involved have identified some plots where they proceeded to carry out the treatments on the basis of the parameters resulting from the application of the TRV model, by varying the dose delivered from the beginning of the flowering season, up to maximum vegetative growth. Preliminarily the farmers provide their application equipments for the inspection and vertical bench calibration test according to the operating parameters provided by themselves. Even in the last year, the comparison between the results of efficacy in plots treated with the standard method and TRV, has highlighted no substantial differences.

Training activity is ongoing in 2012 but after two years of teamwork with farmers we concluded that they are interested in calibration tools to adjust the sprayer according the canopy characteristics but they ask for simple tools.
So, reference tables with application volumes, based on field TRV measurements along the season, on different varieties, cultivation environmets, etc. are intended to be created as already done in the past in other cultivated areas around the world (Furness et al., 1998; Viret et al., 1999).

Importance of calibration on the reduction of drift

Another characteristic of the rural environments in Trentino is the close proximity of residential and cultivated areas. Many housing districts are scattered among orchards and population of rural surroundings has become more and more sensitive to issues about environmental sustainability and spray drift. So, over the years has created the need for regulations to allow the coexistence between fruit growing and non-agricultural activities.
Subject to appropriate conditions of wind and temperature, a proper calibration of working parameters allows among other advantages, immediate and effective waste reduction (Balsari et al., 2007; Doruchowski et al., 2012).
From some recent experimental trials, carried out by comparing equipments with traditional and anti-drift nozzles, has emerged that the maximum degree of reduction in eso-drift losses was obtained by appropriate adjustment of the airflow related to the forward speed of the sprayer and the characteristics of the canopy structure (Fig. 2 and Tab. 1).

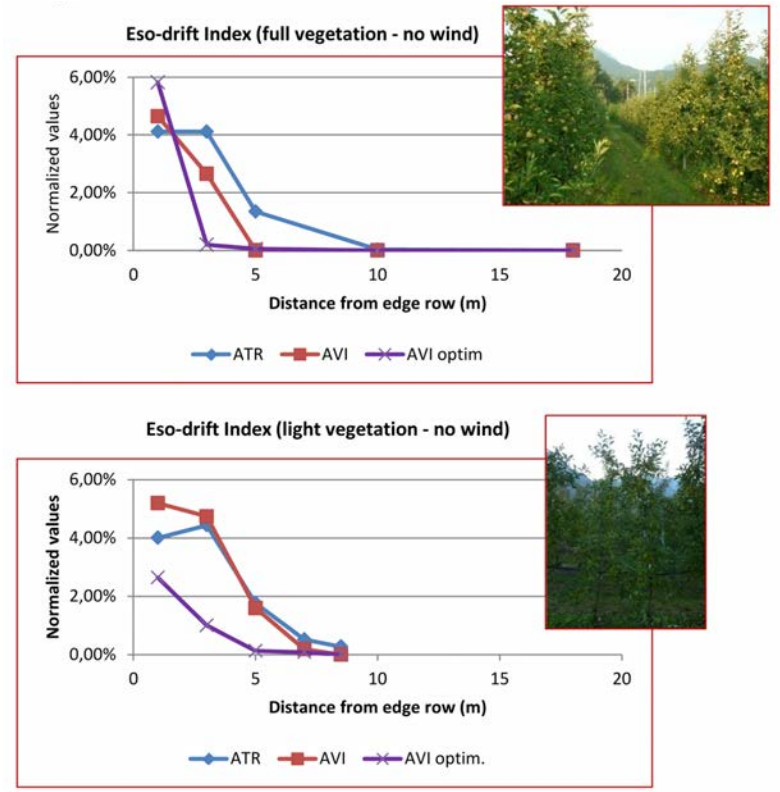

Fig. 3. Effect of sprayer adjustment associated with air injector nozzles (AVI optim.) on drift mitigation: comparison during different development stages of the canopy.

Tab. 1 Main working parameters and conditions during drift tests in 2009.

Equipment	Type and number of nozzles	Pressure (bar)	Operative speed (km h^{-1})	Estimated airflow rate (m^3 h^{-1})	Canopy characteristics
Tower sprayer + ATR + standard airflow rate	Swirl cone 8+8	6.0	6.5	36,000	Full & light vegetation
Tower sprayer + AVI + standard airflow rate	Flat fan air injection 8+8	6.5	6.5	36,000	Full & light vegetation
Tower sprayer + AVI + adjusted airflow rate	Flat fan air injection 8+8	6.5	6.5	19,000	Full vegetation
Tower sprayer + AVI + adjusted airflow rate	Flat fan air injection 7+7	4.5	6.2	19,000	Light vegetation

The evaluation of the correct airflow rate based on field conditions is often difficult to achieve for the farmer. The past difficulties in obtaining a sufficient product deposit in the higher part of the canopy lead the operator to use excessive airflow rates than necessary. For these reasons in the near future will be important to look into this aspect during the training courses organized by the Extension Service of the FEM, which have long proposed to farmers technical meetings on the correct application practices (Fig. 3). The "on field" training approach may allow the one operator to learn from the mistakes of the other and also select the proper fan speed on the basis of the orchard characteristics.

Fig. 4. "On field calibration" meeting organized by the Extension and Experimental Service of FEM in Trentino.

Conclusions

Calibration procedure is one of the more influence factors affecting the final success on spraying application (Gil & Gracia, 2007). Often farmers seem to willingly accept the obligation of inspection thanks to the opportunity given them to calibrate the equipment.

During inspection activity few technical informations and suggestions are achievable by the technical staff of the inspection facilities. This is important also because of the farmer is not familiar with drift reducing devices, that will be even more required during application practices when the Directive 2009/128/EC will be implemented in the Italian legislative system. On this view training during inspection has a key role to make the operator conscious of the most appropriate technical choices for an efficient use of the pesticide application equipment.

Inspection, calibration and drift reduction are strictly linked one each other. Through the constant training and updating of users, these elements can lead the farmer to a higher awareness on how to accomplish a sustainable use of plant protection products.

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Calibration of orchard sprayers – the parameters and methods

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Summary
According to the new EU directive on sustainable use of pesticides (EC 2009/128) calibration of sprayers has to be implemented in the EU Member States. It is also required in the environmental and operators' safety context of different documents and guidelines determining the implementation of good practices or the compliance with standards of certified crop production. The most recent guidelines underline the up-to-date opinion that calibration of sprayer should optimise the on-crop product deposition, and reduce the off-target loss of pesticides. Therefore calibration for orchard sprayers should in particular include aspects regarding spray volume determination, airflow adjustment and selection of the type, number and configuration of nozzles, aiming at high spray application quality and its environmental impact. Spray volume adapted to specific orchard may be calculated based on Tree Row Volume concept. The air flow setting includes adjustment of air volume/velocity, air flow range and air- flow direction/deflection. The type, number and configuration of nozzles are selected aiming at enhanced deposition and distribution of spray in the crop canopy, and reduced spray drift. The practical methods of calibration considering these aspects are proposed in this paper.

Introduction
According to the directive on sustainable use of pesticides (EC/128, 2009) "Professional users shall conduct regular calibrations and technical checks of the pesticide application equipment in accordance with the appropriate training". This requirement has been put in the directive's Art. 8 regarding inspection of equipment in use. It reflects the opinion of legislators that though the calibration does not belong to the inspection of sprayers it is an important complementary procedure making the sprayer apply pesticides in a sustainable manner, i.e. accurately and safely both for the operator and the environment. Furthermore, the calibration conducted by the pesticide user himself raises his awareness on the economic and environmental impact of the technical efficiency and adjustment of spraying equipment.
The requirement about calibration is to be implemented in the Member States. It means the issue will need to be widely communicated among the pesticide users and they will have to be appropriately trained how to perform the calibration procedure. The full advantage of this educative campaign should be taken to present a new approach to the present-day objectives and modern procedure of the calibration, and most of all to convince the pesticide users on the benefits they can get out of it.
Nowadays the calibration is required also in the environmental and operators' safety context of different documents and guidelines determining the implementation of good practices or the compliance with standards of certified crop production. The examples are: Standards of Good Plant Protection Practice (GPPP) (**www.eppo.int**), Guidelines of Integrated Production (IP) (**www.iobc-wprs.org**), Guidelines of Best Management Practice on avoiding point and diffuse sources (TOPPS-BMP) (**www.topps-life.org**), GLOBALG.A.P Control Points and Compliance Criteria (**www.globalgap.org**).
According to the above mentioned documents the main objective of calibration is ensuring that the correct dose of pesticide is applied. However, the most recent guidelines underline the up-to-date opinion that calibration of sprayer should also optimise the on-crop product deposition, and reduce the off-target loss of pesticides, and by that minimise the residue of chemicals in products (GLOBALG.A.P. standards), and mitigate risk of environmental pollution (TOPPS-BMPs). This progressive approach is clearly reflected in the safe use directive and should be transferred to the activities planned in the Member States. Therefore both the trainings on calibration and the procedure of calibration for orchard sprayers should in particular include aspects regarding spray volume determination, airflow adjustment and selection of the type, number and configuration of nozzles, aiming at enhanced deposition and distribution of spray in the crop canopy, and reduced spray drift. The practical methods of calibration considering these aspects are proposed in this paper.

Getting the sprayer operator motivated and committed

Though the sprayer calibration should be a routine job of the fruit growing practice the growers often ignore it for they are not fully aware of its advantages and are afraid of complicated procedure. Therefore the awareness rising and simplicity of calibration are the key conditions that need to be met in order to achieve universality of calibration. Only the large scale of calibration performance can lead to a permanent and firm progress in sustainable use of pesticides.

The calibration of sprayer consists in adequate selection of nozzles and proper setting of application parameters that best suit the specific circumstances, namely: type of sprayer, weather conditions, and most of all the crop characteristics. To say nothing of application technique the adjustment of application parameters can help a lot to optimise the spraying effect. The results of numerous research studies give evidence that the key parameters such as droplet size, airflow direction and velocity/volume, as well as driving velocity influence both on-target deposition and off-target loss of spray. On the other hand this may influence the efficacy and costs of treatments as well as chemical residue level in fruit, which affect the quality of products and finally the profitability of fruit production. What's more precise calibration allows optimising, which often means reduction, of chemical input, and hence further decrease of crop protection costs. After all with a calibrated sprayer the risk of breakdown is much less which gives an advantage of higher work capacity and lower operating costs. Making the growers aware of economic impact of calibration is the best way to motivate them and get them committed to perform calibrations on a regular basis. The financial benefits resulting from lower costs of pesticides, fuel and labour are complemented by environmental ones such as: less drift (less diffuse source contamination), as well as less spray liquid residue in tank and less deposition on the sprayer after treatment (less point source contamination). For the fruit grower it means lower operator exposure to pesticides, enhanced safety and better image of his products and the fruit growing practice.

In order to encourage the growers to calibrate the sprayers the procedure should be "user-friendly", i.e. as simple as possible and yet effective, not costly and verifiable by simple means. Keeping this in mind we will not avoid, however, making basic calculations of spray volume, driving velocity and required nozzle flow rate, which can be made by anyone familiar with a calculator. A simple set of tools including graduated beaker, measuring tape, watch, calculator, rubber hoses, note-pad and pencil, as well as visual assessment of the results will allow the calibration to be performable by the grower himself, at the growers site (in orchard).

The assumed, measured, calculated or determined calibration data should be recorded. The Table 1 comprising all data arranged in a logic order may be used for the record keeping and serve as a calibration guideline and documentation file for the farm audit purposes.

Tab. 1. Table to record the assumed, measured, calculated and determined calibration data

ORCHARD			Spray Volume [l/ha]	AIR FLOW			TRACTOR		NOZZLES		DRIVING		Driving Velocity [km/h]	Nozzle Flow Rate [l/min]	Pressure [bar]
Tree Height [m]	Tree Width [m]	Interrow [m]		Gear / Blade Angle	Output [m³/h]	Range / Direction	Gear	Obroty [obr/min]	Number [pcs]	Size [ISO]	Driving Distance [m]	Driving Time [s]			

Spray volume determination

In the regions with more or less uniform fruit crop structures i.e. uniform training system of slim trees (leaf-wall) and standard interrow distance of 4,0 or 3,5 m the spray volume may be determined based on the tree height, the parameter which may vary between orchards. However in most countries the diversity of orchard types and crop canopy volumes is very big, thus the interrow distance and canopy width also have to be taken into account. In this case the tree-row-volume (TRV) concept seems to be the best way to determine the spray volume (Fig. 1).

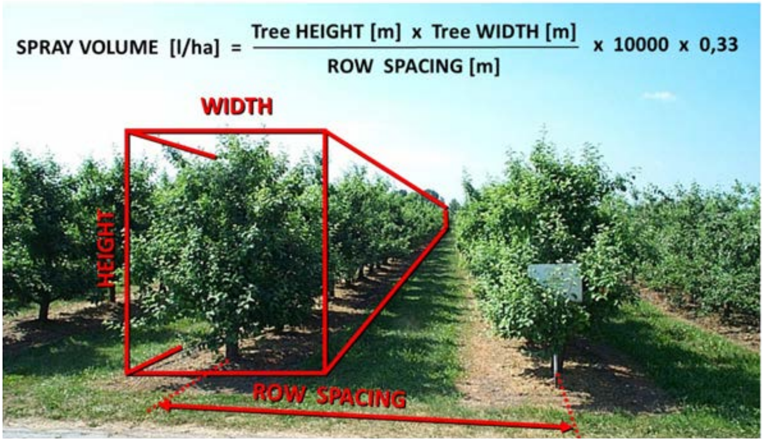

Fig. 1. Tree Row Volume concept to determine spray volume adapted to specific orchard.

For calculation the formula (1) can be used:

$$Q = \frac{H * W}{R} * 10000 * k \qquad (1)$$

where:
Q – spray volume (l/ha)
H – tree height (m)
W – tree width (m)
R – interrow distance (m)
k – unit volume (l/m^3)
The unit volume k expresses a volume of spray liquid per 1 m^3 of canopy volume, which is assumed to produce biologically efficacious spray coverage on the target (canopy foliage). For the orchards in Poland the unit volume k takes value 0,033 l/m^3 which has been tested during the efficacy trials performed in different orchards and with different application methods (Doruchowski et al., 2003). Having used this value in eq. (1) it takes a simple form as below (2):

$$Q = \frac{H * W}{R} * 330 \qquad (2)$$

Thus, in order to calculate the spray volume adapted to the specific orchard the operator needs to measure the basic dimensions of trees and know the tree row spacing.

Air flow adjustment

Three parameters of the air flow should be adjusted: air volume/velocity; air flow range; air- flow direction/deflection (where adjustable). The air flow volume should be big enough to penetrate the crop canopies, but not too big to avoid blowing the spray through the trees (Fig. 2A) and hence reduce on-target deposition and increase the spray loss. Results of field tests show that especially in dwarf and semi-dwarf orchards excessive air flow volume decreases the spray deposition on the tree foliage due to loss of spray being blown through the canopies (Hołownicki et al., 2002). This loss may be reduced by deflecting the air jet backwards up to 30° in sprayers that have individually adjusted air spouts or deflectors with adjustable air slot. (Hołownicki et al., 2000) (Fig. 3).

Fig. 2. Air flow adjustment: A – to big air flow volume resulting in spectacular spray loss;
B – correctly adjusted air flow volume with minimum spray loss.

Thus, the setting of the air flow aims at minimum spray loss because at the same time it is also likely to enhance on-target spray deposition. Since the loss of spray to the air (drift) is spectacular the correct air setting may be assessed visually by the grower himself when spraying on trees with clean water. The air-flow volume and deflection should be adjusted and correlated with the driving velocity of the sprayer so that a complete penetration i.e. full displacement of air in canopy volume is obtained. This is achieved when the crop canopy is filled with spray, and yet no or little spray cloud is observed on the other side of the crop row (Fig. 2B). The lower air-flow velocities should be used at early growth stages as well as narrow and open canopies. Higher air-flow velocities are used for bigger and denser crop canopies, at higher sprayer velocities, and at stronger winds. Finally the range of air flow is adjusted by vane often mounted at the top of the fan or deflector (Fig. 3). In the directed air-jet sprayer the range is adjusted by setting the position and direction of individual air spouts according to the tree size. Having obtained a desired effect during this visual assessment the setting of the fan (transmission gear, fan blade angle) as well as tractor engine RPM and gear box should be recorded in the Tab. 1.

Fig. 3. Cross-flow sprayer with an adjustable air deflector: top vane to adjust air flow range and adjustable air slot to deflect the air flow backwards.

Nozzles

When in orchard, with a sprayer filled with clean water, the number, configuration and type of nozzles are adjusted. The nozzles that spray over or under the tree canopies should be shut-off. The number of nozzles that remain open (n) is to be taken into consideration as the calibration proceeds. If the nozzle position can be adjusted on the sprayer they should be spaced closer where the crop canopy is wider and denser, usually at the bottom.
On modern sprayers multi-nozzle holders are mounted and they should be equipped at least with one set of fine spray nozzles and another one with coarse spray nozzles. Such arrangement allows quick adapting of spray quality to the circumstances, namely kind of chemical, controlled organism and weather conditions. During the wind the coarse spray nozzles should be used to reduce drift and ensure more spray being deposited on the target.

Completing the procedure - driving velocity and nozzle flow rate

For the tractor settings as identified during the air flow adjustment the driving test is performed at a defined distance (e.g. 100 m), and time of driving is measured to calculate the driving velocity according to eq. (3):

$$v = \frac{s}{t} * 3{,}6 \qquad (3)$$

where:
v – driving velocity (km/h)
s – driving distance (m)
t – driving time (s)
Having all needed data recorded in the Table 1 we may calculate the nozzle flow rate (4):

$$q = \frac{Q * R * v}{600 * n} \qquad (1)$$

where:
n – number of open nozzles (pcs)
The last parameter to determine is a pressure for the nozzles assembled on the sprayer to discharge the requested (calculated) flow rate. It is found in the nozzle table.
The last but very important thing to do is setting the determined pressure, checking the actual flow rate of a few nozzles and making corrections in case of deviations from the requested flow rate.
The described calibration procedure including three basic calculations, visual intuitive assessment of air-flow adjustment and simple measurement of nozzle flow rate makes it very simple to be performed by the grower himself and yet effective enough to bring economic and environmental advantages as described above.

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Session 4: Member States shall establish certificate systems for mutual recognition of the certificates

Introducton paper

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Each Member State shall establish certificate systems designed to allow the verification of inspections and recognize the certificates granted in other Member States (acc. Article 8 (6)). The SPISE Working Group (SWG) proposed a certificate system for mutual recognition of inspected Pesticide Application Equipment (PAE) between the Member States. The DG-Sanco welcomed this proposal as a first step so that mutual recognition of inspections between Member States can begin.
The proposed certificate system consists of

- valid test report,
- valid inspection sticker.

The inspection service issues a certificate (test report) stating that the inspection has been carried out correctly.
The test report according EN 13790 (respectively EN 16122) must include at least the following data:

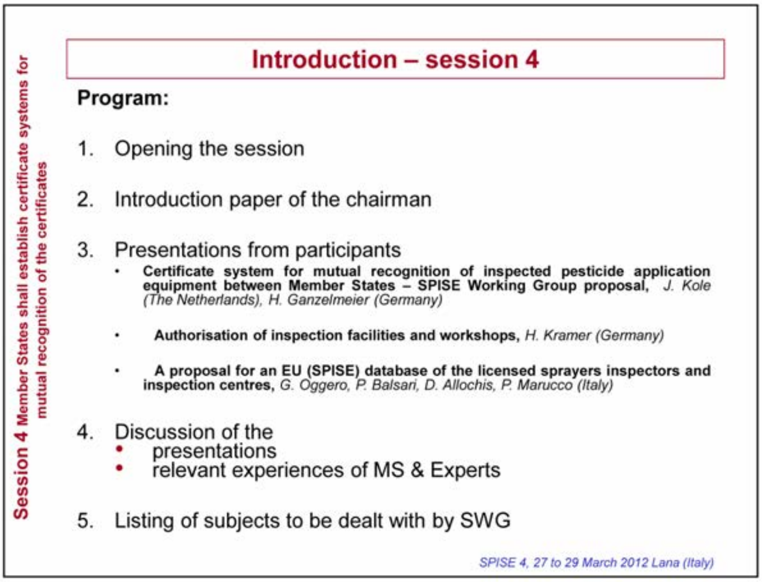
- the name and the address of the recognized workshop what performed the inspection
- the name and the address of the equipment owner,
- the PAE model and the date, the results and conclusion of the inspection.
- Reference to the unique number on the inspection sticker.

The inspection sticker (Diameter: min. 75 mm; Material: self-adhesive foil) must include at least the following data:

- the name and the address of the inspection workshop including MS
- the year and month when the inspection sticker turns invalid in this MS
- the color according ISO 10625 (2012: orange (RAL2004)
- the minimum size of the inspection workshop address field: 60 mm wide, 25 mm length, 25 mm high,
- the writing is any time black.
- Unique number

The inspection workshop fills the inspection sticker in with its address and with the calendar year and month when the next inspection is due and sticks it to the PAE after the inspection has shown that the PAE functions without fault.
The inspections sticker may also be handed out if the PAE has minor defects which the owner undertakes action to remove these minor defects immediately.
The inspection sticker must be clearly visible and stick on the PAE firmly; it must be of such quality that it is destroyed when it is removed.
The inspection sticker turns invalid with the end of the calendar year and month imprinted on it.
PAE which has already been inspected in other Member States is not subject to an obligatory inspection according article 8 § 6 (2) and (3) if the time period since the last inspection carried out in another Member States is equal to or shorter than the time period of the inspection interval applicable in its own territory.
This approach is explicitly welcomed by DG-SANCO since it does not result in more bureaucracy than is actually necessary and makes the procedure easier for farmers.
The definition of what 'minor defects' are should be the same in all MS. If necessary, this should be defined when the corresponding EN/ISO norm is processed.

A further expansion stage aims for the systems to run with a database to prevent counterfeit stickers and reports, and stickers which are issued by way of favour.
One idea is to have online access to the inspection database when monitoring PAE in order to be able to check the legitimacy of the sticker issued. The inspection sticker must therefore include data for identifying the workshop which carried out the inspection. The workshop must also confirm the identity of the equipment to be inspected and the equipment's inspection sticker.



Session 4 Member States shall establish certificate systems for mutual recognition of the certificates

Session 4

Directive 2009/128/EC article 8.6

- Member States shall designate bodies responsible for implementing the inspection systems and inform the Commission thereof.

- Ea... e shall establish certificate systems designed to allow the ... pection ... and recognise the certificates granted in other Men ... vin ... e requirements referred to in paragraph 4 and whe ... he last inspection ... ied out in another Men ... horter than the ... inspection inter... erritory.
- Member S... vour to recogni... issued in other Memb... d that the inspe... erred to in paragraph 1 are complied with.

Responsable bodies

...icate systems

Mutual recognition of this certificates

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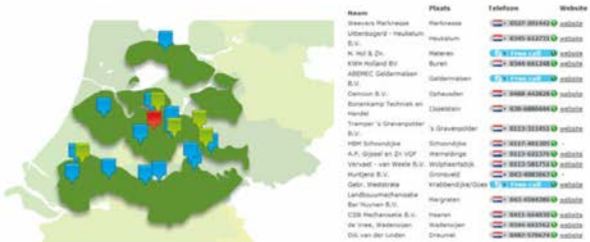
Session 4

Responsible bodies

- Each Member State has own responsible body
- List of recognised workshops / inspection centers
- Central database?



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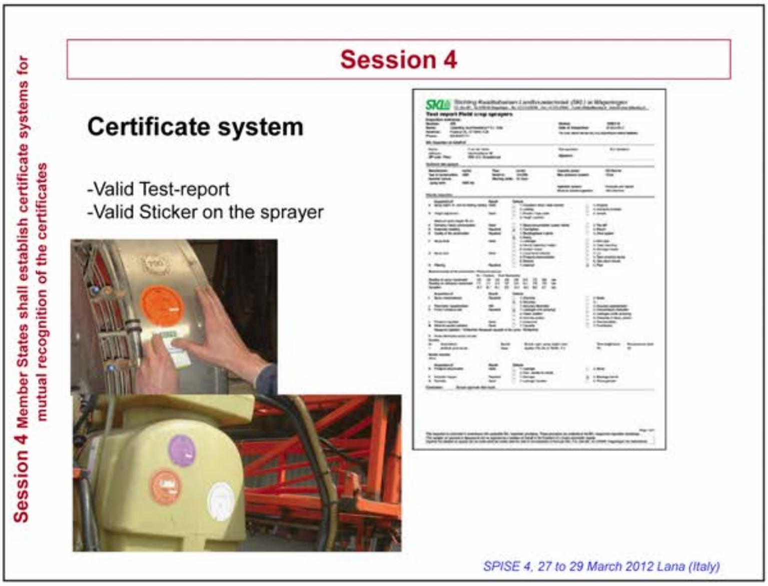
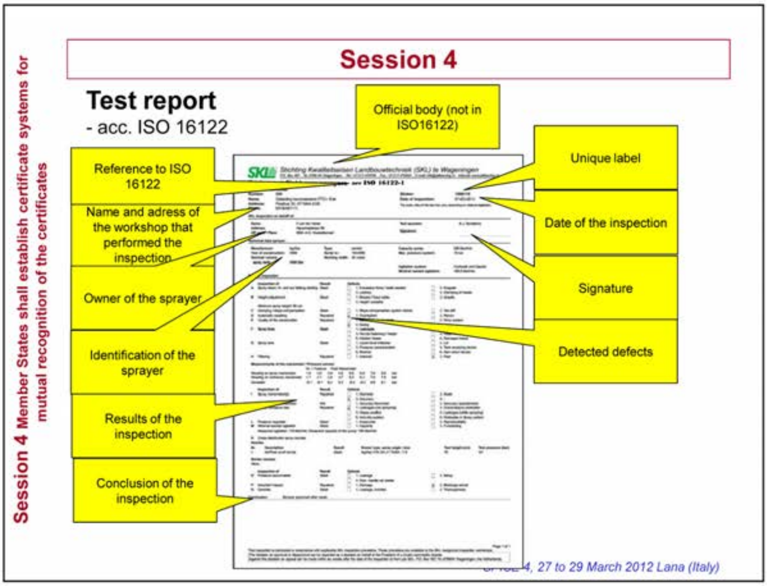

Session 4
Certificate system
-Valid Test-report
-Valid Sticker on the sprayer
Session 4 Member States shall establish certificate systems for mutual recognition of the certificates
SPISE 4, 27 to 29 March 2012 Lana (Italy)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Test report
- acc. ISO 16122
Official body (not in ISO16122)
Reference to ISO 16122
Name and adress of the workshop that performed the inspection
Owner of the sprayer
Identification of the sprayer
Results of the inspection
Conclusion of the inspection
Unique label
Date of the inspection
Signature
Detected defects
Session 4 Member States shall establish certificate systems for mutual recognition of the certificates
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Sticker

-Proposal SWG - not in ISO16122
-Placed on the machine when approved

-Good visible (min diameter 75mm)
-Not removable from sprayer
-Color: according to ISO10625

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Session 4

Mutual recognition

-In EU directive:
The Member States shall 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.

Important for mutual recognition:
The machine has to be tested following requirements of Annex II, standard EN 13790 (respectively EN 16122) (paragraph 4)

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Session 4

Quality management system MS

Objective:
Quality and uniformity of performed inspections

Content:
•Content of the inspection (ISO16122)
•Requirement approved workshops/testteams
    •Testequipment (basic and calibration)
    •Trained testoperators
•Quality assurance
    •Administrative (are all inspections done by approved workshops and certified testoperators)
    •On-site (audits workshops and checks on already inspected sprayers)

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Session 4 Member States shall establish certificate systems for mutual recognition of the certificates

Conclusion of session 4

SPISE recommendations for mutual recognition were discussed, some improvements were recognised

• Need for EU database of official bodies and workshops?
• Identification of PAE (test report & sticker!!!)
• Uniform lay-out sticker, content, color-code, etc.
• Harmonized test-report
•Harmonized requirements workshops / inspection teams
•Need for quality assurance system – SWG label?
•Need for 'recognized' test-equipment
• Mutual recognition is required on the basis of FWD, some regulatory questions could be relevant, each MS have to provide inspections for all PAE
•How to deal with minor defects or rejected PAE in relation with mutual recognition
• Using of inspected PAE in other MS
• SPISE recommendation send to MS for improvements

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Authorisation of inspection facilities and workshops in North Rhine Westphalia

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In North Rhine Westphalia an act (Verordnung über die Anerkennung von Betrieben für die Kontrolle von Pflanzenschutzgeräten - 7823) is existing that rules the procedure of the aproval of the workshops testing PAE's, the requirements to be fullfilled and the inspection through the responsible authority (chamber of agriculture).
The requirements to be fullfilled are:

- Industrial and professional company
- Exact and reliable testing of PAE
- Adequate testing staff with technical qualification
- Adequate testing facilities (mobile patternator, flow control unit, testing facilities for manometers, at least two measuring cylinders - all equipment following the BBA guideline 1 - 3.1.1.)

Each workshop has to bring his testing facilities every second year for a technical check up to the chamber of agriculture. During this check up the mobile patternator, the flow control and the manometer are checked by the authorities. If the requirements after BBA guideline 1-3.1.1. are fullfilled the testing equipment is labelled with a sticker that shows the duration of inspection validity. Additionally a document that shows the relevant measuring results is generated. If a workshop has no approved testing equipment he is not able to do the testing of PAE, because he will not receive the needed stickers for the sprayer testing from the authorities.
The workshops will be supervised by the chamber of agriculture during the testing season. The workshops has to communicate the testing calendar dates to the authorities. Inspectors will visit them during their testing period at least once. If there is a unsteadiness in sprayer testing or a improper testing facility the inspector can stop the testing immediately. If a workshop works not reliable the authority can deny the authorisation of the workshop.


Authorization of inspection workshops
Session 4: Member States shall establish certificate systems for mutual recognition of the certificates
Example: Kverneland is accepted as an inspection workshop (although the workshop is situated in Nieuw Vennep, NL)
• A German agency (situated in Soest) is the official contact
• Inspections of the workshop at Nieuw Vennep (NL) through the chamber of agriculture are not as regular as they are in North Rhine Westphalia
• SKL is inspecting Nieuw Vennep on a regular basis (relevant documents will be submitted to the chamber of agriculture)
⇒ need of a harmonized and accepted guideline
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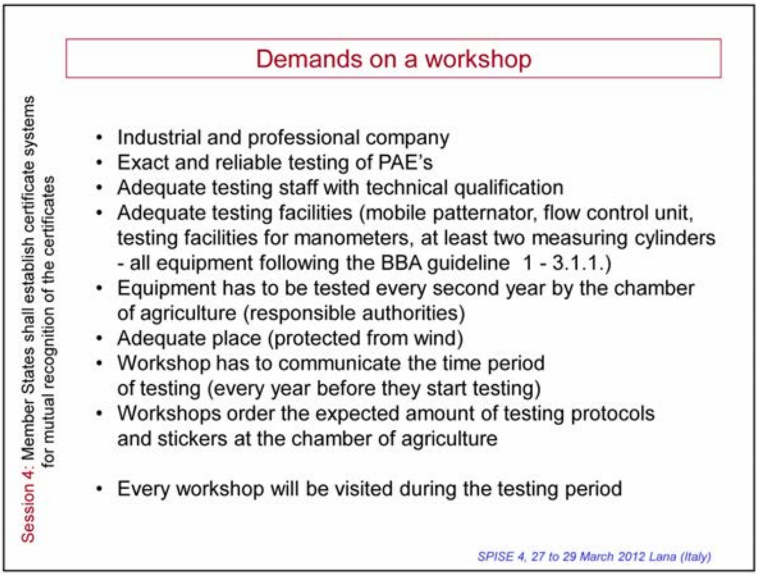
Demands on a workshop
Session 4: Member States shall establish certificate systems for mutual recognition of the certificates
• Industrial and professional company
• Exact and reliable testing of PAE's
• Adequate testing staff with technical qualification
• Adequate testing facilities (mobile patternator, flow control unit, testing facilities for manometers, at least two measuring cylinders - all equipment following the BBA guideline 1 - 3.1.1.)
• Equipment has to be tested every second year by the chamber of agriculture (responsible authorities)
• Adequate place (protected from wind)
• Workshop has to communicate the time period of testing (every year before they start testing)
• Workshops order the expected amount of testing protocols and stickers at the chamber of agriculture
• Every workshop will be visited during the testing period
SPISE 4, 27 to 29 March 2012 Lana (Italy)

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Authorisation of inspection facilities and workshops

Anerkannte Kontrollstelle für Pflanzen-schutzgeräte

Plate for the workshop

Accepted control station for plant protection equipment

SPISE 4, 27 to 29 March 2012 Lana (Italy)

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Summary

- There is a need of a harmonized system to be accepted in each member state
- The testing intervals (not only for the sprayer) needs to be the same (2 or 3 years)
- The documentation/sticker are a useful device to demonstrate the quality of the inspection workshop…
- …and makes cross-border sprayer testing easier

SPISE 4, 27 to 29 March 2012 Lana (Italy)

A proposal for an EU (SPISE) database of the licensed sprayers inspectors and inspection centres

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Summary
In order to guarantee at European level the easy identification of sprayers inspected and to allow mutual recognition of inspections as recommended by the European Directive on Sustainable Use of Pesticides (128/2009/EC) it would be necessary to create a SPISE database enabling to collect the list of the technicians authorized to make inspections of sprayers in use and of the licensed inspection centers. This database should be managed at SPISE level and should be linked to the national databases for getting regular updates.
Actually in Italy there is a public national online database (www.centriprovairroratrici.unito.it) that was realized by the ENAMA working group. Only the sprayers inspected by the test stations listed in this database are recognized all over the country.
This national database contains also the results of all the inspections made in the different Italian Regions and therefore provides a support for monitoring the inspection activity at national level. Independently of the software used at local level for managing data of sprayer inspections, some key information have to be necessarily provided in order to identify the sprayer inspected.
They are the coordinates of the test station, the name of the technician who inspected the sprayer, the name of the owner of the sprayer, the data of the machine inspected, the date of the inspection and its response.

Introduction
European Directive 128/2009/EC (Art. 8, paragraph 6, 2nd clause) requires that: "each Member State shall establish certificated systems appointed to allow the verification of inspections and to recognize the certificates granted in other Member States."
In 3rd clause also it requires that each Member State shall endeavor to recognize the certificates issued in other Member States provided that the inspection intervals prescribed in paragraph 1 are complied with.
In order to guarantee at European level an easier identification of sprayers inspected and to improve the mutual recognition of inspections, it would be necessary to create a "SPISE" database enabling to collect the list of authorized inspection workshops and of the technicians licensed to make inspections of sprayers in use.

The Italian situation
In Italy in the ambit of ENAMA National Working Group (Balsari et *al*., 2007; Balsari et *al*., 2010) a national database (www.centriprovairroratrici.unito.it) has been created. Only the sprayers inspected by the workshops listed in this database are recognized all over the country.
The regional responsible for the sprayer inspection activity communicate at regular intervals to the national manager of the database (that actually is represented by DEIAFA – University of Torino and ENAMA) the updated data of the authorized workshops and of the licensed inspectors, including the eventual suspensions or withdrawals of inspectors licenses. The national manager of database, on the basis of the information collected, updates the national database so that every user (access to the database is free and without any registration) can have access to all updated relevant data and can export them (in xls or pdf format, Fig. 1).

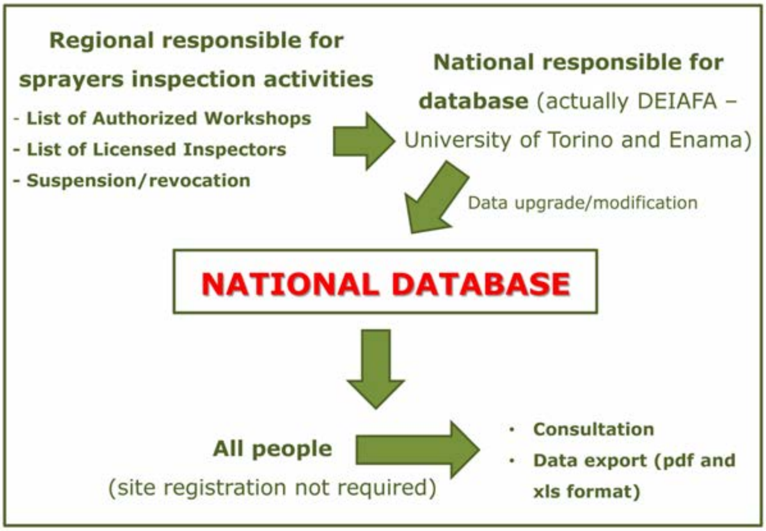

Fig. 5. Management of the Italian database.

Database structure
National database actually contains (Fig. 2):

- Name and reference of the Regional responsible person for sprayers inspection activities (A);
- List of authorized Workshops for each Region (B);
- List of authorized inspectors (boom sprayer, orchard sprayers, lances and spray guns) for each Workshop (C).

Thanks to a specific system of software filters, anyone who enters the database may carry out a targeted research at national or at local level and can get information related to the authorized workshops present in each Region, to the licensed inspectors working in each workshop, to the contacts (phone, email, address) of each sprayer inspection centre and to the name of the person responsible of each workshop (Fig. 3, Fig. 4).
This database will be upgraded with the results of all the inspections made in the different Italian Regions and therefore will provide also a support for monitoring the inspection activity at national level. This activity will be carried out in collaboration with SIAN (National Agricultural Information System – www.sian.it).

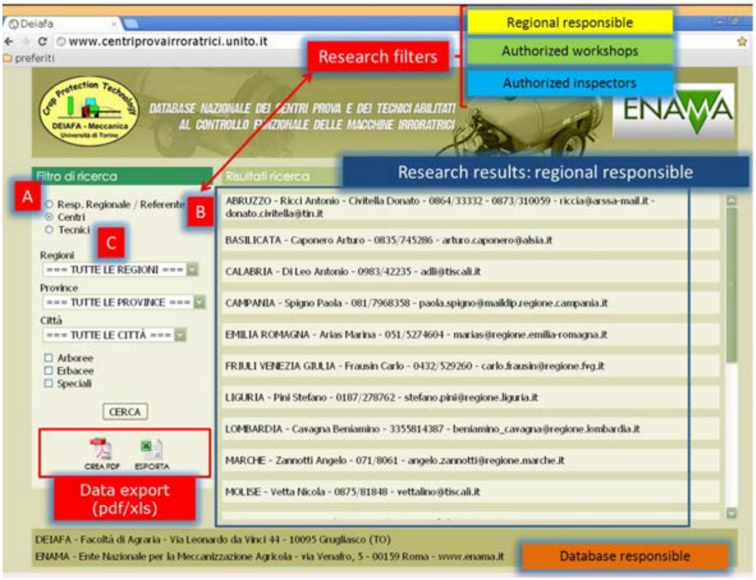

Fig. 6. Database web page of regional responsible.

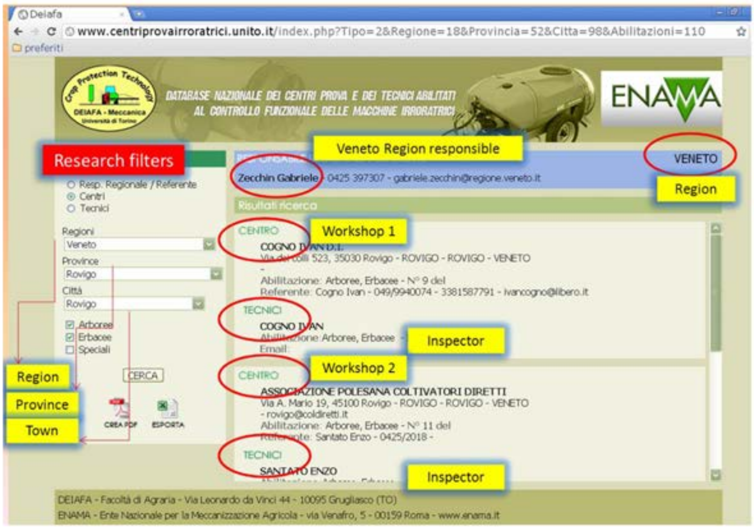

Fig. 7. Example of research results (filter: Workshop in Veneto Region).

Fig. 8. Example of research results (filter: inspector).

Conclusions

The Italian experience could be an useful starting point to be transfer at European level to follow the 128 EU Directive requirements. In order to have in future an European database of the licensed sprayers inspectors and inspections workshop it would be necessary to define inside the SPISE community several aspects of witch the prior are:

- Type of software to be used (it must be able to "talk" with all national database/software)
- Transfer data interval
- Who will take care within SPISE community of the SPISE database
- For data consulting, free access or protected with password

In the meantime it will be necessary that all EU member states set up a national database able to transfer to the European database all main relevant data about sprayers inspections. These should include:

- List of authorized workshops
- List of licensed inspectors
- Type of sprayer inspected
- Identification of the sprayer (type, serial number, picture, ecc..)
- Identification of sprayer owner (farm name, country)
- Date of the inspection and its response
- Inspection identification number (see sticker)
- Date (year) of next inspection.

References

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www.enama.it

www.centriprovairroratrici.unito.it

www.sian.it

Session 5: Training

Training of sprayer inspectors

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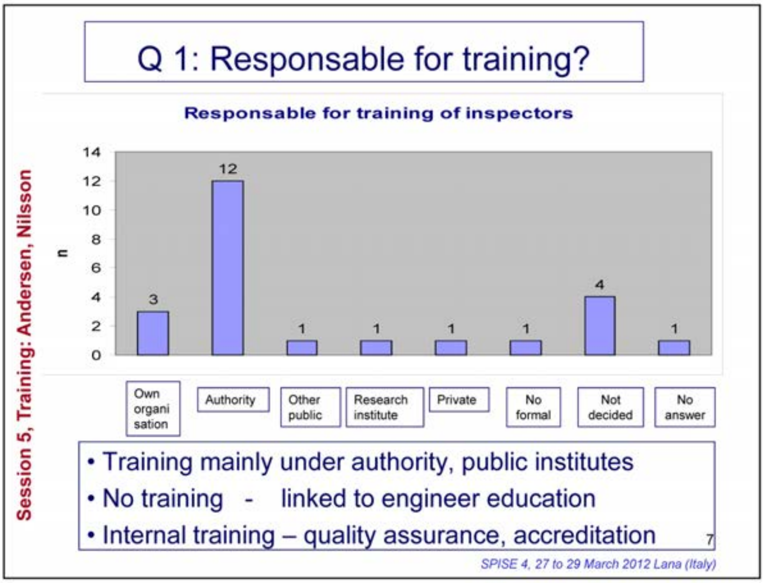
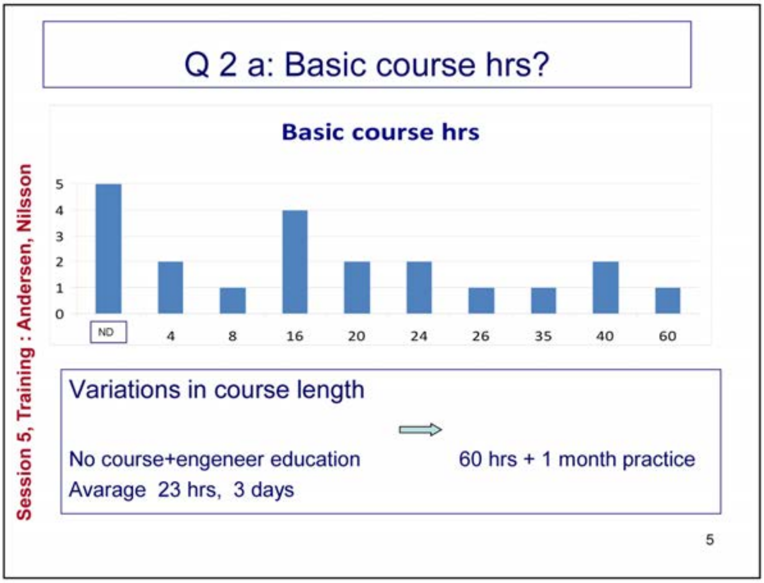
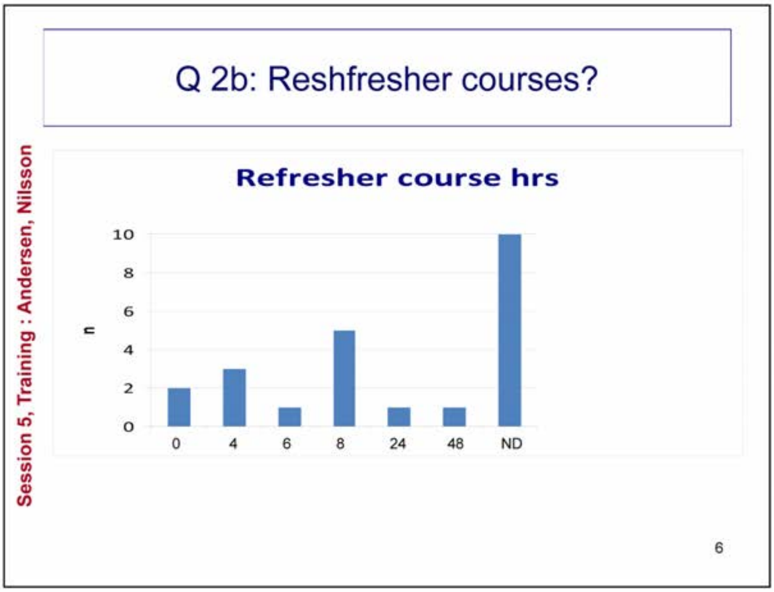
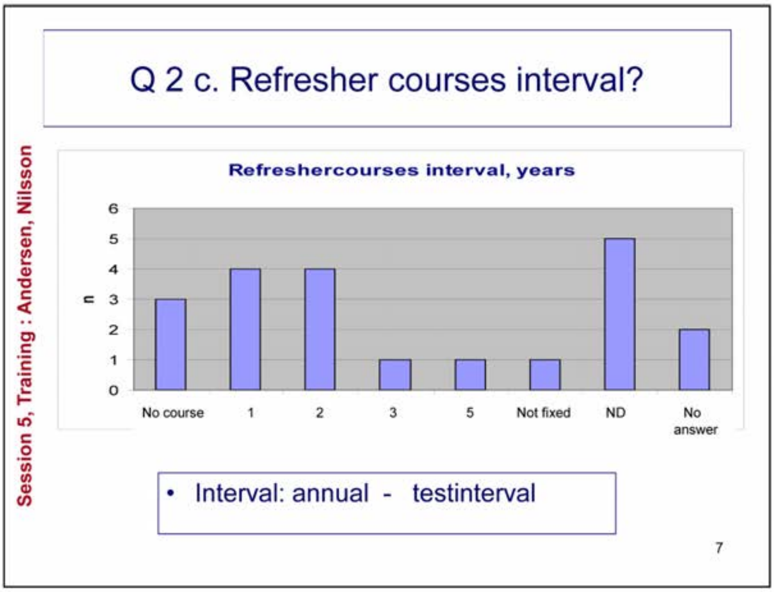
Training of sprayer inspector is an important part for the mutual recognition of inspected sprayers and certification of inspections activities. Inspection of sprayers in use has been active since many years in several countries. In many countries activities are prepared as a result of the Directive for sustainable use of pesticides.
To get an overview of the situation in Europe a survey has been made in February 2012. A questionnaire has been send to the responsible authorities or actors in countries.
The survey show great differences in the national approaches. Mainly, national authorities or public organisations are responsible for the training. Course length varies from four training to 60 hours training plus one month of practise. Examination of inspectors is done often by involvement of authorities but also by separate course arrangers. Countries without formal training or examination occur.
The courses focus mainly on the test-procedure, test regulations, test equipment and practicals with varying proportions. Application technology, advising on calibration and upgrading of sprayers on e.g drift reduction or sprayer cleaning, are part of courses in less proportions. More in voluntary systems than in mandatory control-systems. Voluntary tests are often more ambitious and a part of IPM agriculture.
The training-material is often a collection of regulations, standards, technical material and power point presentations. Special training material or testing guidelines have been developed and are used alone or together with other material.
Courses are conducted mainly as one uniform course for all types of sprayers but can also be special courses for mist blowers, green-house sprayers, seed treatment and aerial sprayers.
A common level or strategy for training and examination of sprayer inspectors would be of great value.
Development of a common approach on the content and level of the training as well as training material may be possible.
Need for changes in existing systems can be foreseen.
As several countries have not yet decided on the training there may be great possibilities for a common approach.


Session 5, Training: Andersen, Nilsson
Q 1: Responsable for training?
Responsable for training of inspectors
n
14
12
10
8
6
4
2
0
3
12
1
1
1
1
4
1
Own organi sation
Authority
Other public
Research institute
Private
No formal
Not decided
No answer
• Training mainly under authority, public institutes
• No training - linked to engineer education
• Internal training – quality assurance, accreditation
7
SPISE 4, 27 to 29 March 2012 Lana (Italy)


Session 5, Training : Andersen, Nilsson
Q 2 a: Basic course hrs?
Basic course hrs
5
4
3
2
1
0
ND
4
8
16
20
24
26
35
40
60
Variations in course length
No course+engeneer education
60 hrs + 1 month practice
Avarage 23 hrs, 3 days
5


Q 2b: Reshfresher courses?
Session 5, Training : Andersen, Nilsson
Refresher course hrs
n
10
8
6
4
2
0
0
4
6
8
24
48
ND
6


Q 2 c. Refresher courses interval?
Session 5, Training : Andersen, Nilsson
Refreshercourses interval, years
n
6
5
4
3
2
1
0
No course
1
2
3
5
Not fixed
ND
No answer
• Interval: annual - testinterval
7

Session 5, Training : Andersen, Nilsson

Q 2 d. Other demands on inspector?

• No demands	5
• Technical/mechanical education	5
• Pestide operator course	1
• Relevant technical experience on sprayers	1

8

Session 5, Training : Andersen, Nilsson

Q 3: General course of different?

• One general course	13
• Different boom- mistblowers	1
• 2 courses: Seed-dressers, others	1
• 3 courses: boom, mistblowers, others (greenhouse)	1
• 3 courses: boom, mistblowers, band (strawberries)	1
• Specialised courses	1
• Special for aerial sprayers	1
• Not decided	5

- Other solution:
  - One basic course plus other sprayers on refresher courses

9

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Q 4 Content in course, avarage % ?

4a: Regulations	11 %	(0-40)
4.b: Inspection procedure,requirements	20 %	(0-40)
4.c: Testing equipment	9 %	(0-20)
4.d: Check, calibration of testing equipment	7 %	(0 – 30)
4.e: Practicals	25 %	(10 – 40)

11

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Q 4 Practicals on course

- Variation 0 hrs – 1 month

• 2 hrs	1 country
• 3 hrs	1
• 4 hrs	3
• 8 hrs	3
• 12 hrs	1
• 16 hrs	2
• 20 hrs	1
• 35 hrs	1

12

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Q 4 Content in course, avarage % ?

4.f: Sprayer technique, application technology	11 %	(0-25)
4.g: Advising on sprayers:	9 %	(0-20)

13

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Q 5 a: Training material?

• Special written manual/guideline	5
• " – " plus ppt, technical info, etc	3
• Manual + protocol	1
• Regulations, standards, ppt, technical info etc	9
• Not decided	5

14

Session 5, Training : Andersen, Nilsson

Q 5 b: Training material available for developing common base material ?

• Yes	8
• No	3
• No because of language	1
• Perhaps	1

- Hesitation because of language and copyrights
- Positive comments on common material

15

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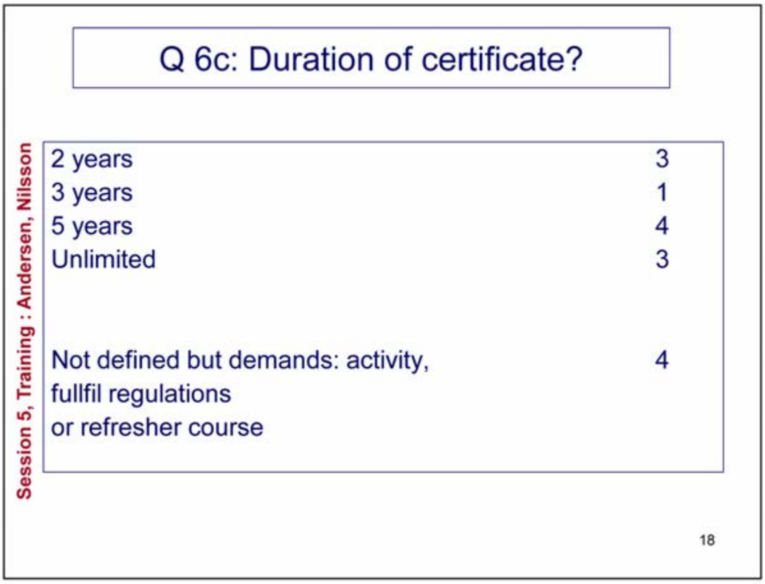
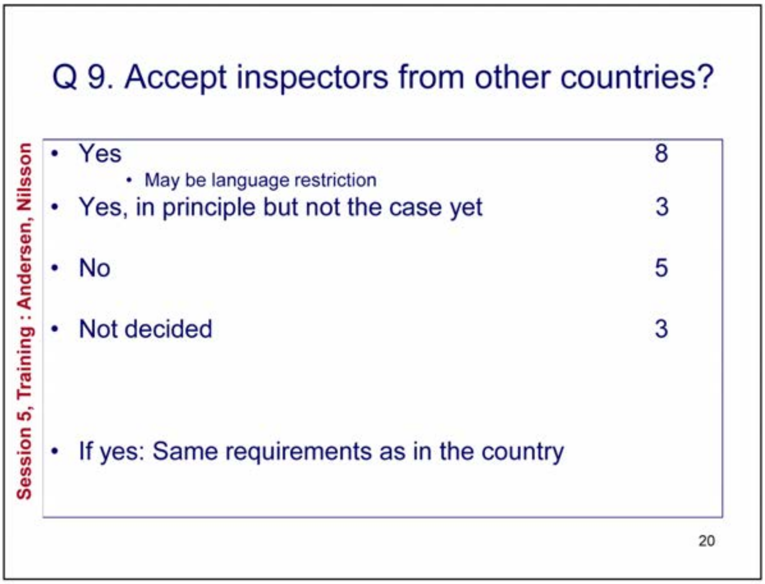
Q 6 a: Examination, type?

• Written	6
• Oral	5
• Written+oral	3
• Written+practical	2
• Oral+practical	1
• No examination	1

16


Q 6c: Duration of certificate?
2 years 3
3 years 1
5 years 4
Unlimited 3
Not defined but demands: activity, fullfil regulations or refresher course 4
Session 5, Training : Andersen, Nilsson
18


Q 9. Accept inspectors from other countries?
• Yes 8
• May be language restriction
• Yes, in principle but not the case yet 3
• No 5
• Not decided 3
• If yes: Same requirements as in the country
Session 5, Training : Andersen, Nilsson
20

Sprayer calibration training – concept and performance

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DOI 10.5073/jka.2012.439.033

Summary
According to the EU directive on sustainable use of pesticides the pesticide users have to be trained on sprayer calibration. A high educative effect of trainings can only be achieved if trainees are motivated and interested in the training, and when the training is performed by the trainer with high competence and practical skills. A concept and programme of calibration training was developed, and then tested by performing the training for trainers. The event was organised in the Research Institute of Horticulture, Skierniewice, Poland, within the Safe Use Initiative (ECPA project). The 10-hour training programme was composed so that the ratio of theory to practice was 40%/60%. The practical part was organized in a way to fully involve the trainees in calibration activities and by that let them gain skills and better understand the procedure. The programme included practical calibration of orchard sprayers by trainees divided into four 5-person teams, followed by verification of the calibration effects during field experiment using water sensitive paper, analyzing he results, and making reports in form of PPT presentations. The elements of competition between the groups made the trainees active, creative and fully involved. The training was found to be instructive and enjoyable.

Introduction
Calibration of sprayer is a crucial action, complementing inspection activity, to make the sprayer apply pesticides accurately and safely. In fact it should be a routine farmer's obligation because the pesticides are too expensive and the environment is too fragile to mandate spray application to non-calibrated sprayer. The experience shows that from the technical point of view the successful pesticide application is a result of using the inspected and calibrated sprayer by the aware and well trained operator.
As required in the directive on sustainable use of pesticides (EC 2009/128) the professional users of pesticides in the EU Member States will have to conduct regular calibrations of application equipment in accordance with obligatory training. Such trainings should ensure that the pesticide users acquire sufficient knowledge on various plant protection issues including sprayer calibration. This may only be achieved if the trainees are motivated and interested in the training, and when the training is performed by the trainer with high competence and practical skills.
The objective of activities described in this paper was to elaborate the concept and perform the calibration training for the trainers (advisors and extension officers), aiming at a high educative effect. The activities were carried out in May 2011, in the Research Institute of Horticulture - Department of Agroengineering, Skierniewice, Poland. The event was organised within the Safe Use Initiative (ECPA project -) in cooperation with Polish Crop Protection Association. The video record of the training course (5-minute video clip: "Facing the real thing - trainers stepping into farmers' shoes") is available on: http://www.youtube.com/watch?v=h3A60xuxqgc

Concept and performance
In order to guarantee a good trainees' perception and gaining practical skills two general assumptions were made: (i) predominance of practical exercises over the theory; (ii) maximal involvement of trainees in the training. The 10-hour training programme was composed so that the ratio of theory to practice was 40%/60%.
The theoretical part started in the afternoon of the first day of training. It was performed in form of PPT presentations (2,5 hours) delivering essential knowledge and meaningful data, supported by a rich illustrative material. The trainees were given the handouts of presentations. The presentations included the following topics:

- Nozzles
    - types - characteristics
    - droplet size – performance and driftability
    - selection and use
- Application parameters
    - targets – spray volume
    - application techniques
    - air flow volume and direction
    - driving velocity
    - nozzle flow rate and pressure
- Procedure
    - assumpions
    - calculations
- Personal safety measures

In order to animate the trainees the presentations were followed by case task exercises and discussion (1,5 hours) which consisted in stating problems and finding solutions. At this stage the trainees were divided into four 5-person teams. Each team was given a separate task to solve based on data and assumptions as shown in Fig. 1, so the trainees could exercise associating facts and making calculations to find out the application parameters best adapted to given situation. The teams were given calibration instructions, nozzle catalogs and calculators, and their task was to complete the table shown in Fig. 1, i.e. to calculate spray volume for given orchards based on tree row volume concept (TRV), calculate driving velocities for given results of driving tests, calculate the required nozzle flow rate, and determine the pressure for given nozzles.

When the trainees were solving specific tasks they recognized the effects of application parameters and understood relationships between them, and they gained skills in calculation the mathematical formulas used in the calibration process. The first day of training was finished with a discussion on the presented topics and results of the case task exercise, and with the instruction on the practical part of the training to be performed in the morning of the next day.

The practical part of the training was organized in a way to involve the trainees in action and keep them all busy. The trainees were working in teams as formed the day before. The task of each team was to perform a full calibration procedure in real situation, check the effects of calibration by designing and performing simple experiment with water sensitive paper (WSP), evaluate obtained results, and report the calibration outcome in form of PPT presentation. The work of teams was observed and evaluated by trainers according to a predefined protocol. The competition between teams and self-evaluation of the effects of their work made the trainees fully committed in what they were doing. Their involvement and commitment was the way to raise interest in the work being performed, fill responsibility for decisions made, and get understanding of the calibration procedure, as well as learn about importance and relationship between application parameters.

TEAM A	TEAM B	TEAM C	TEAM D
Trees H: 3,2 m W: 1,7 m R: 4,0 m	Trees H: 2,2 m W: 1,1 m R: 3,5 m	Trees H: 2,7 m W: 1,4 m R: 4,0 m	Trees H: 3,5 m W: 2,2 m R: 4,0 m
Nozzles 18 pcs TR 80-02 ID 90-015	Nozzles 10 pcs TR 80-015 ID 90-01	Nozzles 10 pcs TR 80-02 ID 90-025	Nozzles 16 pcs TR 80-02 ID 90-03
Driving test - 100 m 58 s	Driving test - 50 m 26 s	Driving test - 100 m 50 s	Driving test - 50 m 30 s
Spray volume .... l/ha	Spray volume .... l/ha	Spray volume .... l/ha	Spray volume .... l/ha
Driving velocity .... km/h	Driving velocity .... km/h	Driving velocity .... km/h	Driving velocity .... km/h
Nozzle flow rate .... l/min	Nozzle flow rate .... l/min	Nozzle flow rate .... l/min	Nozzle flow rate .... l/min
Pressure TR .... bar ID .... bar	Pressure TR .... bar ID .... bar	Pressure TR .... bar ID .... bar	Pressure TR .... bar ID .... bar

Fig. 1. Table used for case task exercise.

The programme of practical exercises included:

- o Practical calibration of orchard sprayer performer in orchard
    - target measurement – spray volume calculation based on TRV concept
    - sprayer-target interaction - airflow adjustment
    - driving test – driving velocity calculation
    - nozzle selection - flow rate calculation
    - pressure setting – flow rate measurement and pressure correction
- o Verification of calibration – experiments with WSPs
    - for fine spray nozzles
    - for coarse spray nozzles
- o Evaluation of coverage on WSPs
    - visually by trainees
    - image analysis by trainers
- o Reports
    - analysis of results
    - elaboration of PPT presentations
- o Presenting results
- o Trainers' evaluation of team performance
- o Discussion
- o Certificates of attendance

In order to perform the practical exercise each team of trainees was given a tractor and sprayer, 3 sets of nozzles (different flow-rates and droplet sizes), full set of personal protective equipment for the group members, and a calibration kit including:

- handy calibration instruction (Fig. 2A)
- table to record the calibration results (Fig. 2B)
- nozzle catalogue
- clipboard with notepad and pencil
- calculator
- stopwatch
- measuring tape

- rubber hoses to collect water discharged by nozzles
- graduated beaker
- brush to clean nozzles
- adjustable wrench
- poles to mark driving distance; hummer
- samples of water sensitive paper (WSP)
- bamboo sticks and rubber bands to attach WSP samples
- latex gloves
- coverage scale for visual assessment of spray cover on WSP (Fig. 2C)
- notebook with Excel and Powerpoint

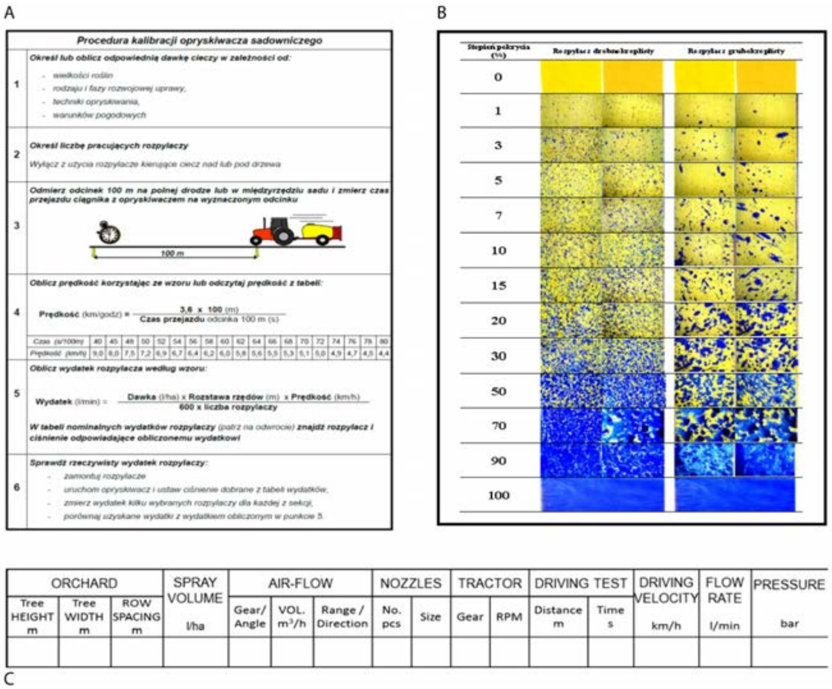

Fig. 2. Elements of calibration kit: A – handy calibration instruction; B – table to record calibration results; C – coverage scale for visual assessment of spray cover on WSP samples.

The teams were given tasks to calibrate their sprayers for specific orchards, for applications in normal and windy conditions. Each team worked in different plot of orchard with different sprayer:

- team A: super spindle orchard – directed air-jet sprayer with multi-spout air discharge system
- team B: slender spindle orchard – axial fan sprayer with a radial air discharge system
- team C: hedge-row orchard – double fan sprayer with a cross-flow air discharge system
- team D: traditional orchard – deflector sprayer with a cross-flow air discharge system

The calibration was performed according to the procedure described by Doruchowski et al. (2012). The effect of calibration was verified by carrying out experiment with WSP samples located in the tree canopies to check the spray coverage obtained at the application parameters as determined by the teams for given orchard and sprayer. The experiments were made both for fine- and coarse-spray nozzles to simulate normal and windy conditions. The average wind velocity at the day of practical training was 2,5 m/s.

The time spent for the exercise in orchard was 3 hours. The next 2 hours was used for indoors activities: visual assessment and analysis of spray cover on WSP using coverage scale and Excel sheet, and preparing reports in form of PPT presentation. Once the trainees were busy with making reports the trainers evaluated the WSP samples with computer image analysis. The results of visual assessment made by the trainees were plotted against the respective results of WSP coverage obtained with vision system, and correlations were determined between those two methods of data analysis (Fig. 3).

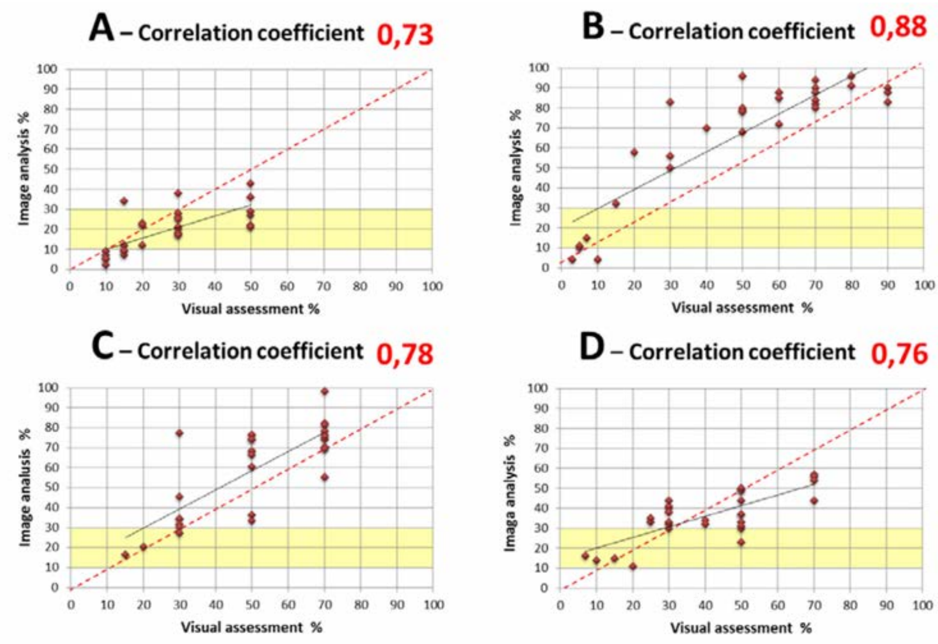

Fig. 3. Correlations between visual assessment and image analysis measurements of coverage on WSP samples obtained by teams A, B, C and D during the field experiment verifying the calibration effects. Preferable coverage range is between 10 and 30%.

The results were presented to the trainees to discuss both the quality of calibration performed by the teams and the reliability of their coverage assessment. It was concluded that the teams A and D obtained the coverage in the trees which was the closest to the preferable range of 10-30%, while the teams B and C produced considerably higher coverage, being possibly the result of the overestimated spray volume. However in team A a few samples were covered less than 10% which may be not enough to guarantee a satisfactory efficacy of treatments. Furthermore the results showed that the visual assessment of coverage was quite reliable in case of all teams (correlations coefficients between 0,73 and 0,88). This evidence was used to convince the trainees that a simple visual assessment of coverage, as a verification of their work, can be trusted and hence may be used during the trainings they conduct for pesticide users.

The last hour of the training was spend for the team reports given by team leaders as PPT presentations, evaluation of the teams' work presented by trainers, discussion and handing out the certificates of attendance.

The training was very well received by the trainees. According to their testimonials it was instructive and enjoyable. The elements of competition between the groups made the trainees active, creative and fully involved. Thus, incorporating the gamification methods in the education process stimulated the trainees' thinking and action, enhanced their perception of the topic and skill gaining, and finally it made the proper calibration process to be imprinted on their minds.

References

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EC/128, 2009: 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. of. J. EU, 24.11.2009, L 309/71.

The necessity of a harmonized procedure for sprayers inspectors training: the Italian activity

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Summary

European Directive on Sustainable Use of Pesticides requires that the people making inspections of sprayers in use have an official license, recognized at national level, released by the competent Authority.

In Italy, Authorities responsible of training and upgrading of sprayers inspectors are Regional and Provincial administrations. They make this job in collaboration with research institutes that provide qualified teachers.

With the aim to homogenize in the whole country the activity of training and licensing of sprayers inspectors the rules for training courses and the criteria for releasing licenses have been defined by ENAMA. Training courses shall have a duration of at least 40 hours subdivided between theory (60% of total time) and practical (40% of total time).Topics treated during courses are: criteria to apply pesticides, main sprayer types used in agriculture and relative components, test methods and equipment used to carry out the inspections of sprayers in use and to adjust them. The exam to get the inspector license shall consist in: a) filling of a questionnaire with multiple answers (at least 80% of answers have to be correct); the questions are selected among a database approved by ENAMA Working Group; b) oral test; c) practical exam consisting in the complete inspection of one sprayer.

In order to guarantee the same quality level of sprayers inspections in the different European countries and to guarantee the mutual recognition of inspections made it is considered necessary to reach in short terms an agreement to harmonize the activity of training, licensing and upgrading of sprayers inspectors across Europe.

Introduction

European Directive 2009/128/EC (Art. 8) requires that: " pesticide application equipment in professional use shall be subject to inspections at regular intervals". The quality of the result of a sprayer functional inspection is closely related to the knowledge and the professionalism of the person that has made the inspection. From these persons depend also the inspection activities success especially in terms of feedback that the farmer could have from it. For these reasons it is very important that these people have access to appropriate training bodies appointed by the competent authorities.

According to the results of a survey made within SPISE in 2009, one of the main requirements that workshops were asked for operating as authorized sprayers inspection centres was an adequate education background of the technicians (Balsari, 2009). Nevertheless the contents of this education background were not homogeneous among Member States and also the duration of the specific training courses for inspectors was different within a range between 10 and 60 hours.

An insufficient qualified training of technicians licensed for the inspection of sprayers in use could lead, in some cases, to a not appropriate execution of the inspection and therefore could originate problems for mutual recognition of inspection results between EU Member States.

The Italian situation

Actually in Italy, Authorities responsible of training and upgrading of sprayers inspectors are Regional and Provincial Administrations and ENAMA (National Board for Agricultural Mechanization). They make these activities in collaboration with research institutes (mainly University) that provide qualified teachers.

With the aim to harmonize the activity of training and licensing the sprayers inspectors, the rules for training courses and the criteria for realizing licenses (Fig. 1) have been defined by the National Technical Workgroup (NTW) coordinated by ENAMA and DEIAFA -Torino University (Balsari at *al*., 2007 and Balsari et *al*., 2010).

Inside the NTW has been decide that, to be admitted to the training courses for getting the sprayer inspector license it is necessary to have at least a secondary school license. Teachers of the training course shell be highly qualified and selected among University personnel, technical managers of the Regional administrations and sprayers expert.

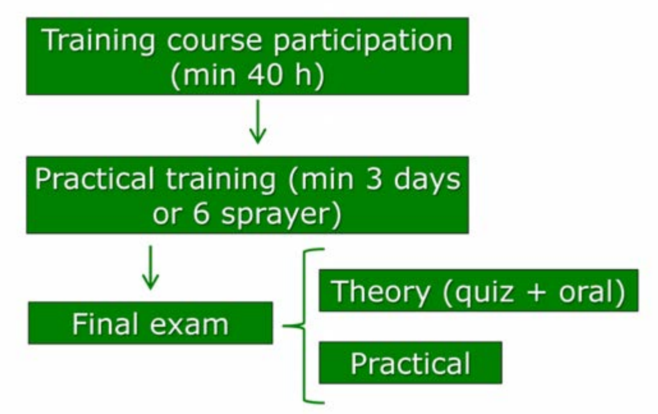

Fig. 9. Steps of the inspectors training courses.

The training course shell be of 40 hours at least and divided between a theoretical part (about 60% of total time) and a practical one (Fig. 2). Items that must be treated during the training courses and that are even defined at national level are summarised in Table 1. Management of the hours for each single item is up to organiser of the course, times values reported in the table are just indicative.

Fig. 10. Training course for inspectors: practical (picture TESAF – Padova).

Tab. 1. Topics of the course defined by Enama Technical Working Group

TOPIC		**HOURS**
General criteria that governs the distribution of plant protection products and their influence on the effectiveness of application, environmental safety and operator safety.	THEORY	3
Different types of sprayers: classification, components, features, criteria of choice	THEORY	8
Main types of nozzles used on sprayers.	THEORY	2
Different levels of pulverization and spray patterns obtained with different types of nozzles; relationship between flow rate and pressure: (+ practical exercises).	PRACTISE + THEORY	3
Main sprayer components, functionality of hydraulic circuit and description of possible operating functional problems of sprayers	PRACTISE	6
Equipment and test benches used for functional inspection: specifications and minimum requirements	THEORY	5
Parameters to examine during functional inspection and their limits of acceptability	THEORY	3
Practical examples of how functional inspections of orchard and field crop sprayers are carried out	PRACTISE	8
How functional inspection of orchard and boom sprayers is carried out	THEORY	2
TOTAL		**40**

Upon completion of the course each candidate must perform a practical training (specific for each type of sprayers- field, orchards, other- for which he has request the license) with a minimum duration of 3 days (or at least 6 sprayers inspected, Fig 3).

Fig. 11. Practical training (picture DEIAFA – Torino).

The verification of the knowledge acquired by the technicians who followed the training course is carried out through a final exam which is divided in three parts:

1. filling of a questionnaire (at least 30 quiz) with multiple answers (at least 80% of answers must be correct); the questions are selected among a database of 137 questions defined by ENAMA NTW (Fig. 4);
2. oral test: mainly focused on wrong answers given in the questionnaire
3. practical exam: a complete inspection of a sprayer (one for each type for which the license is requested, Fig. 5)

Fig. 12. Final exam: filling questionnaire (picture: CRA-ING – Monterotondo – Roma).

Fig. 13. Final exam: practical examination (picture: DEIAFA - Torino).

The overall assessment of the candidate and therefore the delivery of the inspector license is up to an official Commission of three persons that shall include at least one of the teachers who made the training course. The inspector license is conferred only to the candidates who passed the final exam.
The inspector license does not expire unless suspended or revoked:

- due to the established irregularity of inspector actions;
- as a result of repeated and unjustified absence at refreshing courses organized by Regional Administrations.

All authorized inspectors (and workshops) are listed in the national database (www.centriprovairroratrici.unito.it).
Following the guideline defined by the National Technical Workgroup coordinated by Enama and DEIAFA, 15 sprayer inspector training courses have been carried out in Italy until 30 April 2012.

Conclusion

An appropriate inspectors training is mandatory to have a good sprayer functional inspection. The Italian experience could be a useful starting point to harmonize, inside the SPISE Community, the activity of training, licensing and upgrading of sprayers inspectors across Europe in order to guarantee the same quality level of sprayers inspections in European countries and the mutual recognition of the inspections made.

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Training of inspectors for the periodic inspection of spraying equipment in a system of authorised mechanic workshops

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Summary

Within a system of authorised mechanic workshops personal must be well trained in order to conduct the inspection according to technical requirements. The presentation outlines the start training program for inspectors and organisation and contents of successive courses in order to keep the personal up to date with technical and regulatory aspects. The first day of the course deals with legislation, technical requirements, test stands, responsibilities, authorities, etc.. The second day is practical and contains information about sprayer function, nozzles, sprayer cleaning and other technical aspects. There is a specific program for field sprayers and air blast sprayers. A special course is offered for the inspection of spray gun equipment. The training course ends with a written test and an interview. Mechanic workshops have to apply for official stickers annually and have to prove that the inspectors are trained and have passed the test successfully.

Introduction

Within a system of authorised mechanic workshops, personal must be well trained in order to conduct the inspection according to technical and legal requirements.
In Germany a system of authorised mechanic workshops is established while e.g. in Belgium state employed persons carry out the sprayer inspection.
In Germany the federal Plant Protection act made sprayer inspections mandatory for air assisted sprayers in 2002, for field sprayers even earlier. The states (Länder) are responsible with respect to establish administration and the conduct of inspections for sprayer in use and have established the organisation according to the state structures (Koch et al., 1998).
In Rheinland-Pfalz the administration in terms of authorisation of workshops, supervision of the inspection quality as well as supervision of official inspection stickers on sprayers in use is the responsibility of the ADD (Aufsichts- und Dienstleistungs-Direktion, Trier). In addition the DLR RNH (Dienstleistungszentrum Ländlicher Raum Rheinhessen-Nahe-Hunsrück, Bad Kreuznach) is designated as the competent authority responsible for the periodical function check of testing equipment and training of test operators (Anon, 1993).

DLR RNH organises training of test operators

1. Annually offered training program for beginners meaning for persons who want to get the certification as an authorised inspector.
Annually we have about 20 – 30 beginners and offered 3-day-course which is structured in:
Day 1: general aspects, guidelines, legislation, responsibilities, application for authorisation
Day 2: Field sprayer - practical issues, test stand, knowledge about sprayers and sprayer function, nozzles, drift and drift reduction, sprayer cleaning, electronic devices, …
Training at test stand, operation of test equipment
Day 3: air blast sprayer - practical issues, test stand, knowledge about sprayers and sprayer function, fan types, nozzles, drift and drift reduction, sprayer cleaning, …
Training at test stand, operation of test equipment
An extra course is organised for persons who are certified only for spray gun equipment.
Persons who apply only for field sprayer inspection or air assisted sprayer inspection respectively have to attend day one and two or day one and three. Those who want to get a certificate for both sprayer types have to attend the full 3-day program. The course ends with a multiple choice test in writing for each sprayer type. After the written test candidates are interviewed in order to find out misunderstandings and get an impression of their understanding of the relevant issues.
Usually candidates get the information about a course via personal invitation or from the mechanic workshop where they are employed because the workshops have to have trained personal. Nevertheless each person has to apply itself for the course because the certificate is issued to the person not to the workshop. This has been decided because mechanics may change their employment and the certificate will be accepted in any other state.

Persons who want to attend the course are asked to be prepared for the course. It is well known that persons very often will not finish the course successfully in case they have no technical understanding and experience with sprayer technique. Thus as prerequisite to attend the course only persons with a technical education and knowledge in agricultural machinery are accepted.
The training course ends with a test in writing with 20 questions which is a multiple choice test.
Questions cover aspects like:

- Technical/functional issues
- Test equipment
- Conduct of test
- Technical requirements
- Administration/responsibility
- Organisation
- Knowledge about nozzles, drift, drift reduction, environmental aspects

The test in writing is followed by an interview and the final decision about the candidate.
After passing the test successfully the candidate will receive a certificate which enables the person to carry out inspections of sprayers in Germany, i.e, this certificate is accepted in any other state in Germany. The mechanic workshop has to demonstrate to the authority that certified personal is employed and carries out the sprayer testing.
2. Refresher courses are offered in 3-4 years interval, decided by DLR RNH and ADD, depending on novel procedures, legislation and requirements
Certified persons have to attend the refresher courses. An example of the refresher course program could be:
Responsible Authority (ADD)

- Evaluation of reports
- General information on the authorising procedure

Competent Authority (DLR RNH)

- New legal requirements
- Conduct of sprayer inspection according to JKI-Guideline 1-3.2.1 (ISO)
- Handling of test fluid
- Procedure of the regular inspection of test stands (2-year interval)
- New technical developments, nozzles, equipment and procedure of sprayer cleaning, electronic devices

Herbst Prüftechnik:

- Software for sprayer inspection and for spray scanners
- How to use electronic test stands for field and air blast sprayers

The program depends on recent developments, new requirements, test standards, environmental aspects, drift reduction, nozzles, of sprayer cleaning, etc.
Presently the number of trained inspectors is:

for field sprayers	172
for orchard/vineyard sprayers	154
for gun sprayers	22

Conclusions

Training and authorisation of test operators within a system of authorised mechanic workshops have been proved itself in practice as an appropriate measure to fulfil the legal requirements of the mandatory sprayer inspection. The legal obligation of the sprayer inspection is a function test. Crop adapted calibration, crop specific sprayer adjustment or training of applicators is not included. Such issues might be due to extension and advice activities and shall not be implemented into the mandatory sprayer tests. The training program in the first step ends with a test and a certificate which enables the person to do inspections in Germany. Refresher courses are offered in 3-4 year intervals depending on what aspects and developments have to be updated.

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Bescheinigung

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hat an einem Lehrgang für Prüfpersonal über die Kontrolle von Pflanzenschutzgeräten für Flächen- und Raumkulturen gemäß Landesverordnung über die Kontrollstellen zur Prüfung von Pflanzenschutzgeräten teilgenommen und die erforderlichen fachlichen Kenntnisse und Fertigkeiten nachgewiesen. Er ist somit berechtigt, Pflanzenschutzgeräte für Flächen- und Raumkulturen gemäß § 7 der Pflanzenschutzmittelverordnung vom 17. August 1998 (BGB1. I, Nr. 59 S 3029) in der zur Zeit gültigen Fassung zu prüfen.

Lehrgang am: 07. bis 09. Februar 2012
Lehrgangsort: Bad Kreuznach

Bad Kreuznach, den 22. Februar 2012

Im Auftrag:
H. Knewitz
(Horst Knewitz)

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Fig. 1. Certificate of a mechanic (example), showing that the person successfully passed the training and the test.

Session 6: Miscellaneous

An overview of the defects on tested orchard sprayers in Belgium

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In Belgium, the inspection of sprayers is performed by official and mobile teams ruled by two regional inspection authorities, ILVO and CRA-W. The management of the inspection is done by the Federal Ministry for Consumer Protection, Public Health and the Environment (FAVV). Inspection authorities need to have an ISO 17020 certification, consequently the Belgian inspection is completely independent and objective. FAVV delegates the inspection to one inspection service per region (one for the Walloon part and one for the Flemish part). In this way inspection results are centralized and easily consultable. The inspection results are a very useful tool to have an overview of the general condition of the Belgian sprayers. Those results can be helpful when advising on changes in legislation. They can also be used as an instrument to advise fruit growers and farmers how to improve their spraying machines, or what points they have to pay attention to when buying a new or second-hand machine. Therefore, a detailed overview is made of the inspection results on orchard sprayers for the 5th inspection cyclus (3 years: 2008-2009-2010).

Fig. 1. Measuring nozzle flow rate and spray pressures.

Key words: sprayers, inspection, results, defects

1. Introduction

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

In many ways, the mandatory inspection of sprayers in Belgium differs from inspections in other European countries. The inspection is carried out by two official bodies : ILVO (Flemish region) and CRA-W (Walloon region). Those two official bodies are also accredited according to ISO 17020 (BELAC) 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 inspection according to 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 at this place. All over the country test locations are hired in a way that farmers/contractors don't need to travel distances > 15 km with their sprayers. At this moment about 20.800 machines are tested every 3 year, mainly boom sprayers (87%) but also orchard sprayers (9%) and greenhouse/horticulture/floriculture sprayers (4%). The inspection procedure is based on the analytical principle which means that all parts of the machine are tested separately. On average, one inspection team carries out about 12 inspections a day. 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. The inspections can be performed at a very competitive price from 76€ for all orchard sprayers.

Fig. 2. Inspection van with test equipment.

2. The diagnosis principle and rejection procedure for orchard sprayers

The protocol of inspection developed in Belgium fits the EN 13790-2 for 90% in terms of inspected criteria. The inspection methodology is based on the analytical principle which consists in measuring separately and independently the performance of the different parts of the sprayer. In this way, the defect(s) can be determined and a precise diagnosis can be made. No spray distribution measurements using a patternator are performed.

This analytical principle can be illustrated for the check of the pressure stability. The pressure stability is described for an orchard sprayer in EN 13790-2 (paragraph 4.2.2.) as follows: "There shall be no visible pulsations caused by the pump". If one follows a simple inspection protocol, the inspection can be stopped after observing pressure pulsations on, for example, the working manometer.

Following the analytical principle, further measurements, observations and analysis are carried out to determine the exact cause of the pressure pulsations. Indeed, pressure stability depends on several factors such as the pressure in the air-bell, the state of the diaphragm of the air-bell, the state of the induction and exhaust valves and the membranes of the pump, the air-tightness at the induction side of the pump, etc. With the analytical principle all these factors are measured or observed to determine the precise cause of the pressure pulsations and to advise the user on how to solve the problem.

Up to 53 criteria are checked on the sprayer, some are checked visually (agitation, blower, etc...), others are measured (pressure, nozzle flow rate, nozzle spacing, volume/hectare, etc...). All checks and measurements are encoded and stored in a computer with tailor-written software. The analysis is done automatically and the inspection report is printed on site.

The dysfunctions are listed in this report and classified according to their seriousness to disturb sprayer 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 of the sprayer if it significantly disturbs spray results or safety and if its origin is imputable to the user (lack of maintenance). Moreover, for objectivity reasons, the dysfunction leading to a rejection of the sprayer always has to be determined in an indisputable and objective way (measurements). Thus, not all checked criteria lead to a rejection of the sprayer.. Moreover, the same defect criterion could lead to different consequences (rejection or not). From the 53 checked criteria, only 16 can potentially lead to a rejection of the sprayer.

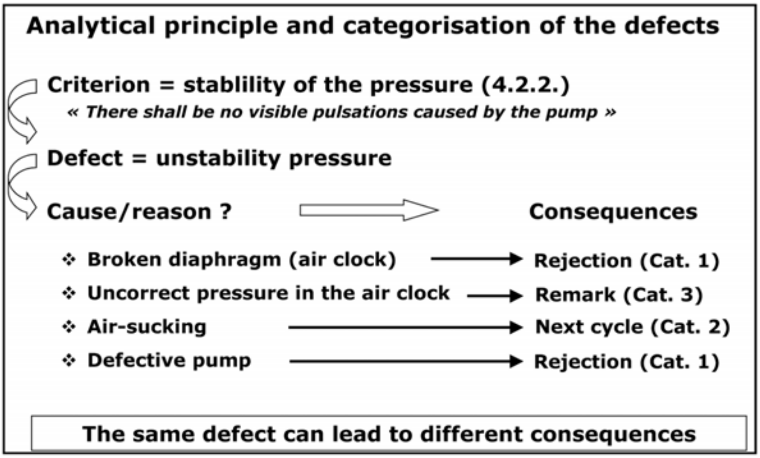

Fig. 3. Analytical principle and categorisation of the defects.

The defects observed during the diagnosis are divided into three different categories:
Category I are defects that automatically result in a rejection. Faults within this category must be repaired within four months and the sprayer must be submitted for retesting.
Category II defects do not result in rejection, but should be repaired before the next inspection. This means that the user has three years time (= one inspection cycle) to repair these defects.
Defects of **category III** are only added for information reasons and are aimed at improving the general operation of the sprayer. The user is completely free to follow these comments.

3. Overview of the defects of orchard sprayers

This overview is based on the inspection results obtained in the 5th inspection cyclus (2008-2009-2010) in the Flemish region. 1.557 orchard sprayers were inspected and 152 (9.7%) of them were rejected during the first passage. A sprayer can have several defects from different categories, or from one category (e.g. 2 defects cat. I). Also sprayers that were inspected successfully can have defects from category II or category III.

3.1 Defects of category I

Defects of category I lead to rejection of the sprayer. The defect must be repaired and the spray must be re-inspected within 4 months. Between the first and the second inspection it is allowed to use the sprayer.

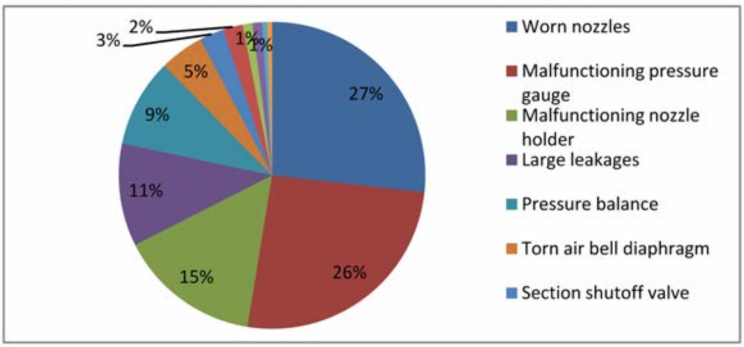

Fig. 4. An overview of category I defects during 2008-2009-2010 (Orchards sprayers).

Within category I defects, the largest number of rejections was caused by worn nozzles (27%). The nozzles are first tested on the sprayer and when the flow results measured on the sprayer are not satisfying (average flow rate deviates too much from nominal flow rate) they are removed from the boom and placed on a specific nozzle test bench to measure their individual flow rates. When the deviation between the average flow rate of the inspected nozzles and the nominal flow rate also exceeds the threshold value on the test bench, the complete nozzle set and sprayer are rejected.
When the measured flow rate on the test bench meets the threshold then the problem is situated at the nozzle holder. Bad nozzle holders are responsible for 15% of the rejections.
Malfunctioning pressure gauges cause the second highest number of rejections (26%). The sprayer pressure gauge is checked by comparison with a reference manometer placed on a nozzle holder. The whole measuring range is tested, generally from 2 to 15 bar depending on the type of orchard sprayer. When the deviation exceeds 10% the pressure gauge is dismantled from the sprayer and tested on a pressure test bench. When the deviation is also higher than 10% on the test bench, the pressure gauge and the sprayer are rejected.

Fig. 5. Testing the sprayer manometer.

Although the user is asked to pay attention to leakages, this criterion often poses problems. Leakages are still responsible for 11% of the rejections. Possible leakages are observed for spraying pressures from 5 to 15 bar and are measured using a measuring cylinder and a chronometer. Leakages higher than 30 ml/min are considered as major leakages (Cat. I), leaks below 30 ml/min are classified as minor (Cat. II). Major leakages (pump, tank, pipes, etc.) are considered as critical and automatically lead to a rejection of the sprayer.
The pressure balance between the left and right section is a major parameter to ensure equal feeding of all nozzles. The pressure deviation between the sprayer manometer and the pressure at the boom, but also between the left and the right section(s) should be as small as possible. A manometer is placed on the left and the right section(s) to check the pressures. The mean pressure is calculated from the results of all section manometers, and if the pressure deviation of one or more sections exceeds 10% the sprayer is rejected. There can be different reasons for pressure heterogeneity: sections and/or feeding pipes of different length, clogged filters in the sections, blocked or strangled feeding pipes, and a defective distribution block. According to the weighted analysis, only the last two defects lead to a rejection of the sprayer. About 9% of the sprayers are rejected as a result of an unequal pressure between the left/right sections.
A torn air bell diaphragm is responsible for 5 % of the rejections. A torn diaphragm is one of the main causes of pressure instability. The pressure pulsations are detected on the working manometer as a rapid oscillation of the needle. Additionally, the inflating pressure of the air-bell is checked (1/3 to 1/2 of the spraying pressure). A broken diaphragm is detected when water squirts from the inflating valve. Another cause can be a defective pump. But this defect occurs much less frequently (1 %).
A number of Cat I problems also appear less frequently. Heterogeneity of the nozzle sets (type, size, angle) (0.5 % of the rejections) is nowadays less of a problem. User awareness on the importance of this parameter is higher than in the past. Also defects involving sprayer regulation system are less frequent. Only a few of the rejected sprayers are affected by a defective pressure valve (2.1%), a defective distribution block (2.6%) and malfunctioning sensors, flow meter or computer (0,5%).

3.2 Defects of category II

Category II defects do not lead to a rejection of the sprayer but the user is encouraged to repair these effects as soon as possible. Anyway, these defects have to be repaired by the next inspection (3 years later). If not repaired, these defects will result in a rejection.

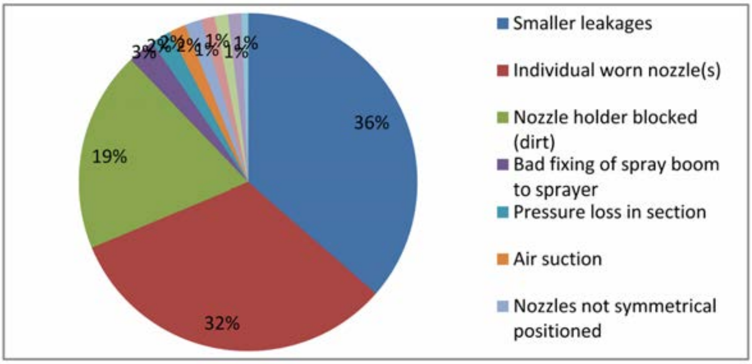

Fig. 6. An overview of category II defects during 2008-2009-2010 (Orchards sprayers).

Three major items are responsible for 87% of the Category II defects i.e. small leakages (36%), worn or blocked nozzles (32%) and partly blocked nozzle holders (19%). Small leakages mainly occur at hoses and nozzle holders but also a number of other sprayer components can show smaller leakages such as the pump, the filter housing and the shut off valves.

Second item are individual worn or blocked nozzles. It happens that only some individual nozzles of the set are worn or dirty (32% of the Category II defects). Those nozzles are clearly marked in the inspection certificate but don't need to be replaced in case the average nozzle flow doesn't exceed the limits. In most cases, it concerns nozzles that are partly blocked due to dirt because fruit growers have the habit to replace their nozzles by new ones every time they are called for an inspection.

Third important item is pressure loss caused by dirty or partly blocked nozzle holders (19%). Partly blocked nozzle holders can cause a significant pressure drop with lower flow rate as a consequence. These nozzle holders are also clearly marked in the inspection certificate so the owner can solve the problem by replacing or deblokking the nozzle holder(s).

Furthermore there are also some smaller category II defects that are rarely noted.

A rejected sprayer can also display defects from this second category.

3.3 Defects of category III

Defects of category III never lead to a rejection. The user is simply encouraged to repair the determined defects of this category. Those defects are less important, but their reparation will improve pray quality or user comfort and safety.

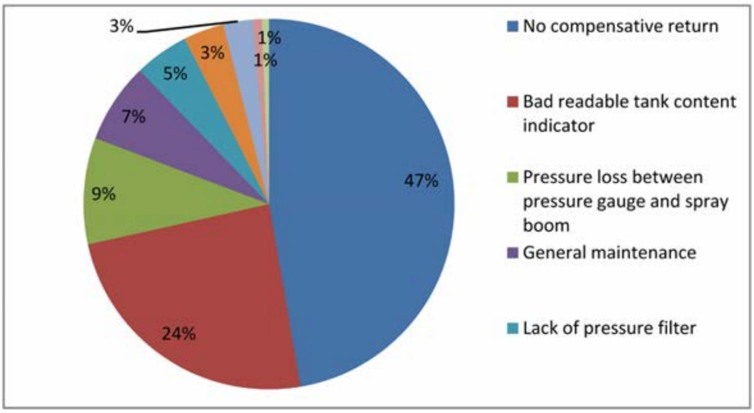

Fig. 7. An overview of category III defects during 2008-2009-2010 (Orchards sprayers).

Many old sprayers don't have the pressure compensation (47%). The user has to adjust the working pressure when he closes a section in order to obtain the same rate. Also a large number of problems concern the readability of the tank content indicator (unreadable or defect: 24%). Further on, 9% of the sprayers show a pressure drop between the working pressure gauge and the spray boom (9 %). The pressure drop value is registered on the inspection certificate. This gives the owner the possibility to adjust the pressure at the working gauge to obtain the desired pressure at the spray boom. Furthermore some smaller items are noted, such as bad general maintenance (7%), lack of a pressure filter (3%) and wrong air bell pressure (3%).
There are also a large number of smaller remarks that do not often occur .

4. Conclusions

The fruit growers 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.
Since the start of the inspection in Belgium, **fruit growers became far more aware** of the negative effects of a badly maintained sprayer resulting in a significant decrease in the number of rejections. However continuous information and training is still necessary to maintain or even improve the current maintenance level of the sprayers.

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Assessment of nozzle flow rate measurement methods for the inspection of sprayers in use

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Introduction

According to the directive 2009/128/EC by the end of 2016 all the sprayers in use working in the EU member states shall be inspected at least once. After that date, inspections shall be repeated at regular intervals, not longer than 3 years after 2020. The inspection protocol in most countries is based on the EN 13790:2003 standard for field crop and air-assisted sprayers, which now is under revision to be harmonized with the above-mentioned directive. This standard establishes the measurement of the nozzle flow rate as the only way to assess the liquid distribution uniformity in air-assisted sprayers. For field crop sprayers, there is also the possibility of determining the spray distribution uniformity of the sprayer booms by means of spray scan devices.

Nozzle flow rate measurements can be made detaching the nozzles from the sprayer and measuring the flow rate of each single nozzle on a measuring bench or with the nozzles mounted on the sprayer using, if required, different kinds of nozzle adaptors to convey the liquid flow to the measuring device (Fig. 1). In order to make the nozzle flow rate measurements on the sprayer easier, air-tight adaptors are often used in several manual and electronic benches. This kind of adaptors are said to cause inaccuracies in the flow rate measurement of spray nozzles. Osteroth (2007) showed that the nozzle air flow rate measured with air-tight adaptors is higher than the real value in the case of air injection nozzles working at less than 10 bar. Besides, the measured error is higher with flat fan nozzles than with hollow cone nozzles. The author advices the use of nozzle air-tight adaptors just for comparison purposes.

Fig. 1. Nozzle flow rate measurement in an air assisted sprayer.

Vanella *et al*. (2011) tested many flat fan and some hollow cone nozzle models with several nozzle flow rate measurement, air-tight adaptors and showed that the use of this kind of adaptors increased the flow rates of air induction and extended range flat fan nozzles. In the case of air induction nozzles, plugging the air holes increased the flow rate. The increase in flow rate decreased with nozzle pressure. The increase of the nozzle flow rate depended on the nozzle type but it was not affected by the nozzle size. The use of funnel shaped adaptors instead of the air-tight adaptors increased the liquid flow measurement accuracy but it requires holding a graduated cylinder under each nozzle.

In a previous work in our Institute (Camp, 2008), several nozzle flow rate measurement benches using air-tight adaptors were compared with other measuring systems. In that case, Albuz® ATR nozzles at 7 bar mounted on an air-assisted sprayer were used. Results showed a small variation among the measurement values obtained with the same bench and also a small deviation (less than 2%) between the average values obtained with the different benches. It has to be taken into account, though, that only

a single nozzle model working at the same pressure was used in the test.
In this paper, the flow rate measurements on different nozzle models working at different pressures and using several measuring systems are presented and their accuracy is compared using a statistical analysis.

Methodology

Three methods for measuring nozzle flow rate in the sprayer inspection were assessed:

a. volume measurement with a graduated cylinder and a stopwatch, using a hose for liquid collection at the nozzle outlet. The hose connection with the nozzle is not air tight, so it is necessary to hold a graduated cylinder below the nozzle outlet level to avoid any leaks. It is a methodology that is often used for the measurement of nozzle flow rate on air-assisted sprayers (Fig. 2, left).

b. electronic bench with an air-tight adaptor at the sprayer nozzle outlet. The bench performs an electronic measurement of each single nozzle flow rate based on the time taken for each nozzle to fill a cylindrical container. Air-tight adaptors are required to convey the liquid from the nozzles to the containers so that the nozzle output can be locatred below the container level. In this case, the flow rate measurement is also made with the nozzles mounted on the sprayer (Fig. 2, centre).

c. nozzle flow rate bench for detached spray nozzles. The nozzles have to be dismounted from the nozzle holders and placed on the bench board. The bench is equipped with a pressure gauge and a flowmeter (Fig. 2, right).

Fig. 2. Three methods for nozzle airflow measurement, graduated cylinder and stopwatch (left), air-tight nozzle adaptor (centre) and nozzle flow rate bench (right).

Eleven nozzle models were chosen from four manufacturers (tab. 1), in order to determine the effect of the nozzle type (flat fan or hollow cone) and the air injection technology on the accuracy of the liquid flow rate measurements.
Three different nozzle sizes were selected from each nozzle model, randomly selecting four nozzle units for the combination of nozzle model and size. The flow rate for each single nozzle was measured at three different pressures in a two replication basis. The working pressures for each nozzle model were selected within the pressure range advised by the sprayer manufacturer.
A general lineal model was used for the analysis of the variance of the flow rate measurement results. The following main classes were considered in the model: measurement method, nozzle type, nozzle size and working pressure. The interaction between nozzle type, nozzle size and pressure were also taken into account in the model. The calculations were made using the SAS 9.0 software.

Tab. 1. Nozzle models and working pressure used in the tests. Air injection nozzles are depicted in italics

Manufacturer	Nozzle models and size	Pressure (bar)
Albuz®	API 110 02, 03, 04(1)	2, 3, 4
	AVI 110 02, 03, 04(1)	3, 5, 7
	ATR yellow, orange, red(2)	5, 8, 10
	TVI 80 015, 02, 03(2)	5, 8, 10
Teejet®	XR 110 02, 03, 04 VS(1)	2, 3, 4
	TXA 80 015 VK, TXB 80 02, 03 VK(2)	5, 8, 10
Hardi®	F 110 02, 03, 04(1)	2, 3, 4
	INJET 02, 03, 04(1)	3, 6, 8
Lechler®	*IDK 120 02, 03, 04*(1)	2, 4, 6
	TR 80 015, 02, 03(2)	5, 8, 10
	ITR(3) *80 015, 02*(2)	5, 8, 10

(1) Flat fan; (2) hollow cone; (3) only two nozzles sizes were selected for this model

Results

No significant differences were found between flow rate measurements of the nozzles mounted on the nozzle holder, using a hose to collect the spray, and measurements of the same detached nozzles in the nozzle bench. However, when the air-tight adaptors where attached to the nozzle outlet, in most of the cases the flow rate values deviated from those measured using the hose. Positive deviations were measured when all flat fan and air injection hollow cone nozzles were used (Fig. 3), whereas they were negative for hollow-cone standard nozzles (Fig. 4).

Tab. 2 clearly shows that deviations for flat-fan nozzles –especially air injection- working at a lower pressure are significantly higher than those obtained at higher pressure. This trend was also noticed when air injection hollow cone nozzles were used, but not for the standard hollow cone nozzles (tab. 3), where they remain similar. Nozzle size does not affect the deviation values for any type of the tested hollow cone nozzles, and only a minor effect was noticed for flat fan nozzles (tab. 4).

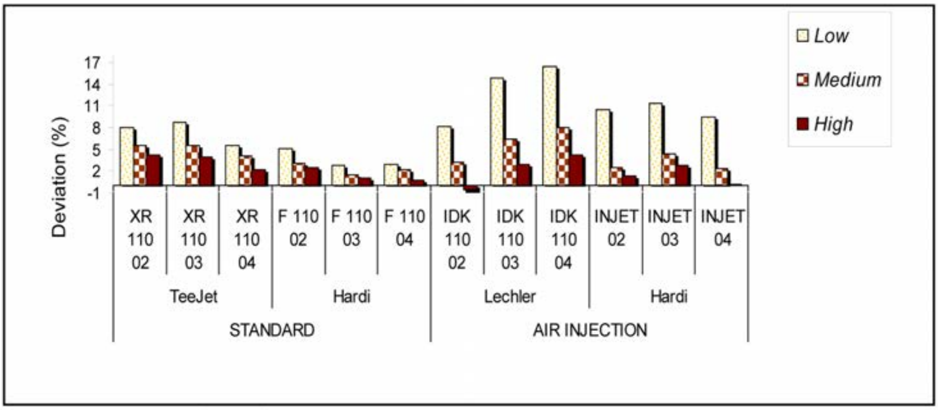

Fig. 3. Deviation values for the flow rate measured at three working pressures with an air-tight adaptor on different models of flat fan nozzles. The value of the pressure level (Low, Medium and High) is different for each nozzle model, so that it fits within its working pressure range.

Tab. 2. Average deviation values (%) between the flow rate measured with an air-tight adaptor and with a hose. The value of the pressure level is different for each nozzle model, so that it fits within its working pressure range. Values followed by the same letter within each row are non-significant (p<0.01)

Flat fan nozzle type	**Pressure**		
	Low	Medium	High
Standard	4.55 a	3.17 b	2.23 b
Air injection	11.55 a	4.78 b	2.26 c

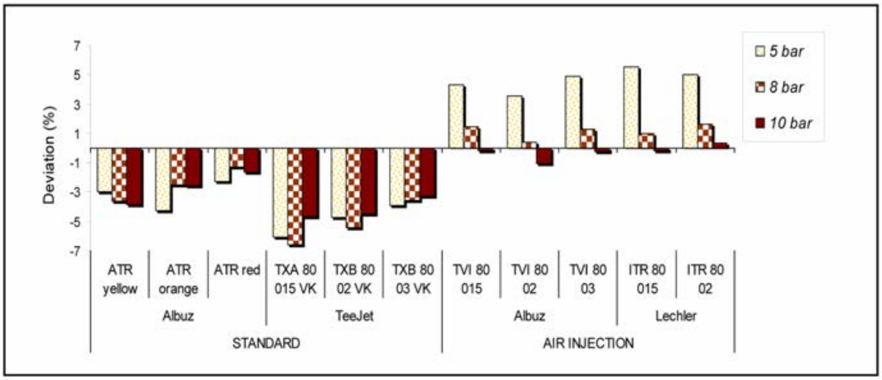

Fig. 4. Deviation values for the flow rate measured at three working pressures with an air-tight adaptor on different models of hollow cone nozzles.

Tab. 3. Average deviation values (%) between the flow rate measured with an air-tight adaptor and with a hose. Values followed by the same letter within each row are non-significant (p<0.01)

Hollow cone nozzle type	**Pressure**		
	5	8	10
Standard	-3.50 a	-3.45 a	-3.02 a
Air injection	4.70 a	1.17 b	-0.24 c

Tab. 4. Average deviation values (%) between the flow rate measured with an air-tight adaptor and with a hose. Effect of nozzle size for flat fan nozzles. Size values are those established in ISO 10625:2005. Values followed by the same letter within each row are non-significant (p<0.01)

Flat fan nozzle type	**Size**		
	02	03	04
Standard	4.60 a	3.22 b	2.12 b
Air injection	5.18 a	6.89 b	6.52 b

Discussion

As it was already shown in previous works (Osteroth 2007, Vanella *et al*. 2001), significant differences were found when air-tight adaptors were used for the nozzle flow measurements, compared with the methodologies that don't imply the modification of the spray formation conditions at the nozzle outlet.

According to the results, it is difficult to establish a clear trend for the measurement deviations. In general, but not in all the cases, the difference is higher when the measurements are carried out at lower pressures. In the case of standard hollow cone nozzles the deviations are negative and they are not significantly affected by pressure changes.

Therefore, measurements with air-tight adaptors are in general more reliable when they are carried out at the higher pressures of the nozzle working range. In the case of standard hollow cone nozzles, the measured deviations at 10 bar were always lower than 5%, as it was the case with standard flat fan nozzles working at 4 bar (Fig.s 3 and 4). Nevertheless, it must be taken into account that the EN 13790:2003 standard only allows for a maximum error of 2.5% of the measurement devices used for the inspection of sprayers in use.

The higher deviations were recorded in the case of flat fan air-injection nozzles working on the lower level of the pressure range. This effect may be caused by plugging the air holes with the air-tight adaptors (Vanella *et al*., 2011), although in the case of air-injection hollow cone nozzles, working at 8 or 10 bar, almost no deviations were measured (Fig. 4).

The possibility of a measurement error, in the case of using air-tight adaptors for nozzle flow rate measurement in the inspection of sprayers in use, should be taken into account. However, the fact that these devices have got clear advantages in relation to the other methodologies, make them widely used by the inspection workshops.

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Uniform cross distribution of double flat spray nozzles may be affected by the design of the sprayer

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Summary
According to EU Directive 2009/128/EC pesticide application equipment must function reliably and be used properly for its intended purpose ensuring that pesticides can be accurately dosed and distributed. The transverse distribution of the spray mixture in the target area must be even, where relevant. Spray jets of double flat spray nozzles are angled forward and backward. Depending on the design of the sprayer and boom height, parts of the equipment get splashed by the angled spray jet. Problems arise with lift masts which are fitted very close to the frame of the sprayer. Solutions might be technical modifications of the boom and tube. If technical changes are not possible, the use of flat spray nozzles on the boom is recommended in the critical area in combination with double flat spray nozzles. Results from sprayer inspection are shown with regard to cross distribution.
Oftentimes, the deepness of the scanner patternator is not suitable in order to catch both spray jets of double flat spray nozzles. An upgrade for Herbst scanner patternator SPRAYERTEST 1000 is available. A modified table HV 1000-L with 2m in depth, which is double of the current one, is introduced to deal with that specific problem. An easy replacement of the patternator table in existing operating equipments is suggested.
Key words: Double flat spray nozzles IDKT, cross distribution, mixed mounting of nozzles, longer patternator table

Introduction
According to EU Directive 2009/128/EC pesticide application equipment must function reliably and be used properly for its intended purpose ensuring that pesticides can be accurately dosed and distributed. Double flat spray air induction nozzles e.g. IDKT are popular and in the meantime well accepted by farmers. Their main characteristic is based on a second spray level with most often symmetric set up. That means one spray jet is directed 30° to the front and the other one 30° backwards in direction of travelling.
The European Norm EN 13790 for Inspection of sprayers in use – Part 1 indicates under point 4.8.6 that "Regardless of the distance of the boom above the ground, no liquid shall be sprayed on the sprayer itself". Problematic areas are especially frame parts of the sprayer when the boom is mounted close on a lift mast. It might be that only at low spray height the forward directed spray jet is not interfered as it is the case for e.g. herbicide applications. At higher boom heights most certainly the frame of the sprayer gets splashed. Other designs where booms are attached to a parallelogram the distance between boom and frame of the sprayer is much bigger so that at low and mid boom height the spay jets will not hit the sprayer. Only when the parallelogram is extended splashing will occur for e.g. flower treatment in rape seed. If the frame of the sprayer gets splashed, run off of spray liquid occurs. That should be avoided in order to maintain cross distribution and to avoid any point sources into surface water. Not only the frame of the sprayer can be hit by the spray jet but also tires of trailed sprayers when the axle is translocated backwards close to the lift mast. The norm does not apply if parts needed by function, such as, distance guards of booms get splashed and if dripping is minimised.

Materials and Methods
Cross distribution of new nozzles and already in use have been tested. New nozzles of IDKT 120-04C and IDKN 120-04 POM of each 10 pieces have been measured with a patternator (50 mm groove distance) at Lechler company with a pressure of 2,0 and 4,0 bar at a spray height of 500 mm. Nozzles in use have been tested in a workshop during sprayer inspection. A Holder ES-4 sprayer with 12m boom was equipped with IDKT 120-04C. Additionally, in the mid section of the boom 4 x IDKN 120-04 have been mounted for another series of tests. All measurements have been performed with a Herbst scanner patternator SPRAYERTEST 1000 with a pressure of 3,0 bar at 500 mm spray height.

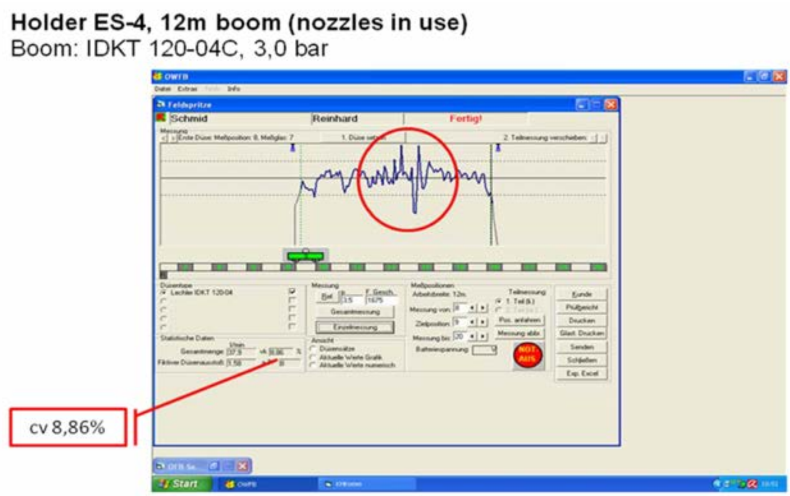
Results and Discussion

New IDKT 120-04 and IDKN 120-04 at 2,0 and 4,0 bar showed good performance with a cv of 1,7 to 3,0%. This result is in accordance with JKI requirements for new nozzles allowing a max. cv of 7%.

Tab. 1. Cross distribution of new IDKT 120-04 and IDKN 120-04. Tested on Lechler patternator.

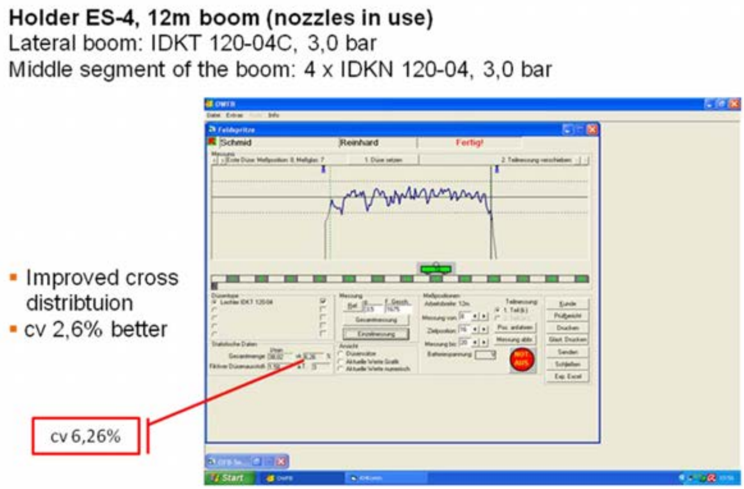
	CV %			
	2,0 bar		**4,0 bar**	
Spray height 500 mm	**IDKT 120-04**	**IDKN 120-04**	**IDKT 120-04**	**IDKN 120-04**
	2,1	2,7	1,7	3,0

Nozzles in use have been mounted on a Holder ES-4 sprayer with 12 m boom. Cross distribution was measured with a Herbst scanner patternator SPRAYERTEST 1000. IDKT 120-04C at 500 mm spray height and 3,0 bar pressure obtained a cv of 8,86% (Graph 1). In the mid section of the boom the frame of the sprayer got splashed. Peaks with under and over dosage occurred and are visible on the graph in the test report. But even though cv was below 10% which is the threshold value for rejection of nozzles.



Graph 1. Cross distribution of IDKT 120-04C nozzles in use. Tested on Herbst scanner patternator SPRAYERTEST 1000

By mounting 4 x IDKN 120-04 in the mid section of the boom an improved cross distribution of cv 6,26% was achieved (Graph 2). In the test report no exceeding peaks are seen in the mid section of the boom.



Graph 2. Cross distribution of IDKT 120-04C nozzles in use in combination with 4 x IDKN 120-04 in the mid section of the boom. Tested on Herbst scanner patternator SPRAYERTEST 1000

The European Norm EN 13790 for Inspection of sprayers in use – Part 1 implies under point 4.9.1 that "All nozzles shall be identical (type, size, material and origin) all along the boom, except where they are intended for a special function for example the end nozzles for border spraying. The mixed setting of double flat spray nozzles with flat spray nozzles e.g. in the mid section of the boom is seen as an exception because of technical reasons when other measures do not solve the problem of splashing sprayer parts. Therefore, German JKI approved recently for boom sprayers the mix of IDKT with IDK/IDKN nozzles (Tab. 2). In the mid section of the boom 6 flat spray nozzles are specified which is in accordance with the width of most boom sections.

Tab. 2. JKI approval of IDKT and IDK/IDKN nozzles (20th of March 2012)

	Boom	**Boom middle section**
G 1932	IDKT 120-03 POM	6 x IDKN 120-03 POM
G 1933	IDKT 120-04 POM	6 x IDKN 120-04 POM
G 1934	IDKT 120-05 POM	6 x IDK 120-05 POM

For farmers the combination of IDKT with IDK/IDKN in the mid section of the boom is easy to perform, cheap and with no negative effects on cross distribution (Graph 2). Further advantages are same pressure setting and same drift reduction (Germany). According to EN 13790, the approach uses same type as compact air induction nozzle, same size, same material and same origin.
Most scanner patternators for measurement of cross distribution have a table with 1,00 m in depth. At 500 mm spray height double flat spray nozzles with 30°/30° angling spread around 0,6 m in-between the two spray jets. To catch both spray jets completely on the patternator an exact reverse of the sprayer is necessary in order to bring the boom into a parallel position along the track of the patternator. For Herbst scanner patternator SPRAYERTEST 1000 an upgrade is available. The scanner patternator table HV 1000-L has a depth of 2,00 m which is double of the current one. The replacement takes only 2 minutes. Especially handling of big booms is much easier and spray jets of any double flat spray nozzle is catched easily.

Conclusion

According to EU Directive 2009/128/EC and EN 13790 no liquid shall be sprayed on the sprayer itself. Double flat fan nozzles may splash on sprayer frame under some circumstances. A mixed mounting of IDKT and IDK / IDKN is favourable when technical modifications on the sprayer is not possible or causes high expenses. For farmers it is an easy way to do, cheap and does not influence cross distribution negatively. Oftentimes, the deepness of the scanner patternator is not suitable in order to catch both spray jets of double flat spray nozzles. A modified scanner patternator table HV-1000L of Herbst with 2m in depth is available. Refitting on all SPRAYERTEST 1000 can be done easily.

References

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Closing Session

The aim of the SPISE 4 Workshop 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.
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.
Many matters could be discussed and some of them clarified during the Workshop. However, many issues remained unsolved. These are to be brought together in **T**echnical **W**orking **G**roups and specified further.
The main issues include:

- How to deal with minor defects/brand new sprayers?
- Define a certificate system for mutual recognition
- Define a simplified quality assurances system
- Define a common risk assessment procedure for excluding PAE from the inspections
- Define a procedure for calibration, sprayer adjustment and drift reducing technology as added values
- Collect from MS available training material and make it downloadable on SPISE website
- Develop a SPISE database relevant for monitoring, mutual recognition …

CLOSING SESSION
1 – Summary of conclusions of sessions 1-5

SESSION 1

Inspections at regular intervals - Inspection of new equipment

Chairmen: H. Ganzelmeier, E. Gil

Closing session

1. Member States (MS) are intensively engaged to implement a mandatory inspection.
2. Boom sprayers and air-assisted sprayers are in the central focus of inspection.
3. How the exemptions (different timetables and inspection intervals) according to article 8.3 will be applied by the MS, is currently inexplicit.

SPISE 4, 27 to 29 March 2012 Lana (Italy)

CLOSING SESSION
1 – Summary of conclusions of sessions 1-5

SESSION 1

Inspections at regular intervals - Inspection of new equipment

Chairmen: H. Ganzelmeier, E. Gil

Closing session

4.The mutual recognition of the inspection between MS is to date relevant and it will be encouraged by EU Directive 128/2009.

5.As a replacement for the missing harmonized standards, the EN 13790 is fully recommended for temporary use.

6.Quality measurements (audits…) have to be developed.

7.No clear position on how to deal with minor defects and new PAE: a special coordination is needed.

SPISE 4, 27 to 29 March 2012 Lana (Italy)

CLOSING SESSION
1 – Summary of conclusions of sessions 1-5

Closing session

SESSION 2
Member States may apply different timetables and inspection intervals with exceptions following a risk assessment and exempt handheld pesticide application equipment or knapsack sprayers
Chairmen: B. Huyghebaert, N. Bjugstad

1.Which is the appropriate sprayer type risk assessment to be able to apply different timetables and inspection intervals according to article 8.3 is still not clear.

2.Most of the Member States have not yet defined for which types of sprayer they will require the exemptions.

3.A common sprayer risk assessment methodology is recommended.

SPISE 4, 27 to 29 March 2012 Lana (Italy)

CLOSING SESSION
1 – Summary of conclusions of sessions 1-5

Closing session

SESSION 3
The inspections shall verify that pesticide application equipment satisfies the relevant requirements
Chairmen: J.-P. Douzals, V. Polvêche

1.ISO/CEN 16122-1-2-3-4 seems able to follow the main requirements of the Directive (Annex II).

HEALTH | **SAFETY** | **ENVIRONMENT**

2.Necessity to develop in short time other ISO standard parts.

3.Necessity to improve the present ISO methodology to inspect the sprayer to obtain a higher reproducibility of results.

4.How to inspect without a harmonized standard (EN 13790 when possible)?

SPISE 4, 27 to 29 March 2012 Lana (Italy)

CLOSING SESSION
1 – Summary of conclusions of sessions 1-5

SESSION 4

Member States shall establish certificate systems for mutual recognition of the certificates

Chairmen: J. Kole, P. Harašta

Closing session

1. Identification of PAE (test report and sticker!).
2. Uniform sticker layout, content, color code, etc.
3. Harmonized test report.
4. Harmonized requirements for workshops / inspection teams.
5. **Need for quality assurance system – SPISE Working Group (SWG) label?**
6. **Need for «recognized» test equipment.**

SPISE 4, 27 to 29 March 2012 Lana (Italy)

CLOSING SESSION
1 – Summary of conclusions of sessions 1-5

SESSION 5

Training

Chairmen: E. Nilsson, P.-G. Andersen

Closing session

The **importance of an adequate inspectors training** has been deeply underlined and considered a priority to have successful inspections. Nevertheless due to resource limitations and how far process is developed in MS:

1. At present it seems difficult to develop a common course plan.
2. At present it seems difficult to develop common training materials.
3. **Good idea to collect training material and course plan for exchange between countries.**

SPISE 4, 27 to 29 March 2012 Lana (Italy)

CLOSING SESSION
2 – Recommendations of the workshop and closing

Closing session

Several requests for the implementation of a Technical Working Group (TWG) for developing common proposals came out from the sessions discussion

TWG has to be activated in order to:

1.Develop a common proposal concerning how to deal with **minor defects.**

2.Develop a common proposal concerning how to deal with **BRAND NEW SPRAYERS**.

3.Define a **common risk assessment procedure** for PAE to be exempted from the inspections.

4.Define a common way on how to "certificate" the workshop activity (**quality assurance**), including the test facilities.

SPISE 4, 27 to 29 March 2012 Lana (Italy)

CLOSING SESSION
2 – Recommendations of the workshop and closing

Closing session

Several requests for the implementation of a Technical Working Group (TWG) for developing common proposals came out from the sessions discussion

TWG has to be activated in order to:

5. Define which are the minimum workshop facilities necessary to make an **appropriate sprayer adjustment** in the case of orchard sprayers with the knowledge of all orchard parameters necessary, to be able to make orchard sprayers adjustment at the workshop during the inspection.

6. **Collect from MS available training material** and make it downloadable on SWG website.

SPISE 4, 27 to 29 March 2012 Lana (Italy)

Closing session

CLOSING SESSION
2 – Recommendations of the workshop and closing

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SPISE 4, 27 to 29 March 2012 Lana (Italy)

Closing session

CLOSING SESSION
2 – Recommendations of the workshop and closing

Several requests for the implementation of a Technical Working Group (TWG) for developing common proposals came out from the sessions discussion

TWG has to be activated in order to:

7. Create a **SPISE database** with all MS authorised inspectors and workshops??
   - Legal aspects
   - Not create too much burocracy
   - Useful for new sprayers
   - Collect sticker types of different EU countries??
   - Database only related to country reference persons?

SPISE 4, 27 to 29 March 2012 Lana (Italy)

Posters

A new test-bench for the inspection and the adjustment of the sprayers employed in the mediterranea tree cultures

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DOI 10.5073/jka.2012.439.021

Summary
The present study relates about the structural characteristics of a trailed test bench prototype suitably designed for the adjustment of the sprayers used for expanded canopy fruit-growing. This test bench is equipped with a droplets intercepting patternator, that can be folded on the bottom of a road trailer during the transfers, through manually operated hydraulic systems.
Furthermore the test bench is equipped with a computerized measure system realized by a measure bench, a computer and an ad hoc software.
Preliminary tests of useful effectiveness were carried out with the still droplets intercepting patternator, through surveys of some fluid dynamic characteristics, very important for the evaluation of the transversal patterns of distribution produced by air assisted sprayers (air-convection or pneumatic sprayers).
On the ground of the obtained results, the patternator is suitable for the evaluation of the transverse patterns of distribution produced by sprayers at present used for treatments to tree cultures 3.5 m high.

Introduction
As known, the new 2009/128/CE Directive presses the Member States for setting up the National Action Plans, directed towards the sustainable use of chemicals, to reduce risks and impacts of pesticide use on human health and the environment (2009/128/CE).
Particularly in Southern Italy, the establishment of „systems which allow the recurring inspection of equipment in use" meets with a widespread indifference, emphasized by the high price of such a service (Severini & Biocca, 2003).
In fact, the inspections of the pesticide application equipment in professional use employed for the main mediterranean crops (e.g. table grapes and olive trees) require suitable test benches, complex preparations and tiring assemblies, high times for carrying out the routine tests (Pascuzzi & Guarella, 2008).
At different time, the Department of Agricultural and Environmental Science of the University of Bari (Italy) planned and built innovative test-benches, suitable for "tendone" trained vineyards (table grapes), for "controspalliera" (espalier) trained vineyards (wine grapes) and for expanded canopy fruit-growing (olive trees, almond trees, and so on) according to these common guidelines (Guarella & Pascuzzi, 2000, 2002):
a) quickness use (fixed point or decentralized service), through the realization of one base common to all the preparations (type-approved road trailer, equipped with the instrumentation for the inspections according to the direction of the ENAMA protocols) (ENAMA, 2010).
b) to be able to place on the afore mentioned base different droplets intercepting patternators, suitable for each one of the orchard vegetation shape and productive area, with the aim to evaluate and to adjust the transverse patterns of distribution produced by the sprayer.
c) speeding up of the phases connected to set up the test-bench, to carry out the inspections and to make the adjustment by means computerization of the surveys and removal of workers' weariness (Pascuzzi et al., 2010).
The present study relates about the structural characteristics of a trailed test bench prototype suitably designed for the adjustment of the sprayers used for expanded canopy fruit-growing. This test bench is equipped with a droplets intercepting patternator, that can be folded on the bottom of the road trailer during the transfers, through manually operated hydraulic systems.

[1] *Each of the authors contributed in equal parts to this work.*

The droplets intercepting patternator

The droplets intercepting patternator is constituted by a vertical metallic outline, that simulates the vegetative and productive area of a tree culture with a training form comparable to a continuous vertical wall.

The bearing structure of the patternator is a rectangle of dimension 1450x3670 mm, realized by a 30x30x3 mm stainless steel square tube, on which sexteen intercepting tools are assembled. Each one of these tools is formed by a set of thin sheets steel, which are planned and inclines in such way to maximize the contact surface with the wet air flow produced by the sprayer.

The intercepting tools have a length of 800 mm, less than the bearing structure witdh (1450 mm), in order to reduce the unavoidable interferences between the wet air flow and the patternator. Really at the side of each one of the afore mentioned tools there is a free window-space for the undisturbed crossing of the wet air flow (Fig. 1). The intercepting tools are then assembled alternatively adjoining to the left and right edges of the bearing structure.

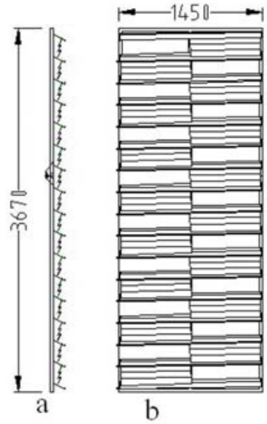

Fig. 14. The droplets intercepting patternator: a.lateral view; b. front view (dimension in mm).

The thin sheets steel of the intercepting tool are assembled so as the intercepted water droplets slide along their surface, flowing into stainless steel manifold and the drain pipe.

These manifolds are designed so that to minimize the drag during the crossing of the wet air flow produced by the sprayer and to drain all the intercepted water, without any overflow of the liquid. The manifolds are sixteen and they are mounted with a distance of 250 mm between each other.

The patternator can be folded for facilitating the transport operations; this characteristic has been obtained dividing the bearing structure into two parts, connected by hinges.

Finally, the patternator allows the adjustment of both pressure driven and pneumatic sprayers, through the analysis of the transverse patterns of distribution produced by the spray tips, or by the diffusers, symmetrically assembled on the right and left sides of the sprayer.

The test bench

The intercepting patternator has been assembled on a road trailer, so that to realize a test bench easily transportable; during the transfers, in fact, the patternator is folded on the bottom of the trailer (Fig. 2a). Instead, the operations of the adjustment of the sprayers are carried out with the patternator placed vertically as shown in the Fig. 2b. In this condition the trailer stability is assured by four manually controlled additional stabilizers, placed at the corners of the trailer (Fig. 2b).

The actions of the patternator take place by means of a manually controlled oleo dynamic servomechanism.

The test bench is equipped with a computerized measure system realized by a measure bench, a computer and an ad hoc software.

The measure bench is made of a stainless steel welded frame with 16 plexiglas containers for the collection of fluids hydraulically connected to an equal number of pressure transducers (Fig. 3). The data processing is carried out by means a software specifically made to manage the test bench.

Fig. 2. The droplets intercepting patternator: a. folded on the bottom of the trailer; b. placed vertically.

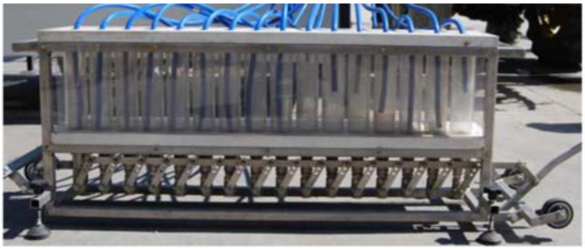

Fig. 3. Front view of the measure bench.

The tests carried out

Preliminary tests of useful effectiveness were carried out with the still droplets intercepting patternator, through surveys of some fluid dynamic characteristics, very important for the evaluation of the transversal patterns of distribution produced by air assisted sprayers (air-convection or pneumatic sprayers).
Particularly, the patternator assembled on the road trailer has been subjected to droplets intercepting tests with an air convection sprayer in order to evaluate the liquid amount intercepted by each one of the intercepting tools and the overall efficiency.
The overall efficiency E_c% has been measured evaluating the amount of the overall intercepted liquid by the patternator Q_r as regards to the liquid amount delivered by the sprayer Q_e (Balsari & Tamagnone, 1997):
The per cent liquid amount C_c intercepted by each one of the intercepting tools has been evaluated by the following ratio: :

$$E_c = \frac{Q_r}{Q_e} \times 100$$

with
Q_c = liquid amount intercepted by each one of the intercepting tools

$$C_c = \frac{Q_c}{Q_r} \times 100$$

The first manifold of the patternator was at 950 mm from the ground of and the highest one at 4950 mm.
The machine employed during the test was a mounted traditional sprayer, Agrimaster Mod. AP355 ALBA, equipped with an axial fan having these main specifications: impeller nominal diameter: 550 mm; distance between the ground and the centre of impeller: 1052 mm.

During the test the sprayer worked at 540 rpm of the tractor power take off and at an operative pression of 2 MPa. Furthermore this machine was equipped with n. 5 spray tips (full cone) simultaneously working, placed on its left side. During the experimental campaign the spray tips inclination has been the same and the fan velocity was constant.
Finally, during the tests the sprayer was stopped and placed so that its rolling axis was 1630 mm from the patternator.
Initially we have collected the liquid delivered by the n.5 spray tips of the machine during a working period of 60 s.
Subsequently the amount of the liquid intercepted by each one of the intercepting tools was measured during a working period of the sprayer of 60 s. This test has been repeated three times (Fig. 4).

Fig. 4. The droplets intercepting patternator under test.

In a second time the velocity of the air flow produced by the fan was measured at points placed at different height from the ground, in front of and behind the patternator. The position of the sprayer as regard to the patternator was just the same of the previous tests.
The evaluation of the three perpendicular vectorial components of the air velocity was made using a Gill Instruments Limited 'Windmaster' ultrasonic anemometer, with the following main technical specifications (Fig. 5): measure range: 0-45 m/s; measure resolution: 0,01 m/s; measure accuracy: 1,5%; direction range: 0-359°; direction resolution: 1°; direction accuracy: 2°.
The measure of the air velocity has been measured in n. 15+15 points vertically placed and spaced 250 mm each other, starting at an height from the ground of 1050 mm: n.15 points were placed in front of the patternator and n.15 points were placed behind the patternator (Fig. 6).

Fig. 5. Evaluation of the air velocity near the patterantor.

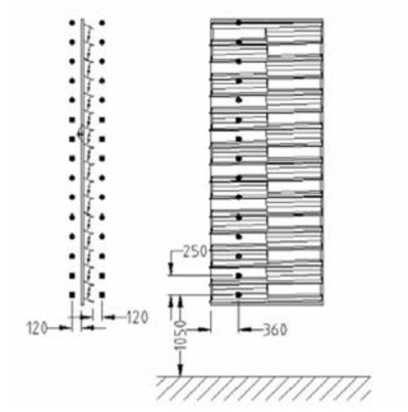

Fig. 6. Measure points of the air velocity (dimension in mm).

Obtained results
Tab. 1 shows the overall intercepting efficiency E_c% of the patternator, evaluated during the tests carried out.

Tab. 2. – Efficiency obtained by air-convection spraying machine under test

Test n.	1	2	3
E_c %	46	48	46

These values of E_c% are acceptable in that the intercepting tools do not fill the whole surface of the patternator, but only a part of it. Therefore there are a set of free windows crossed by the wet air flow without any liquid interception.
Fig. 7 shows the average quantities of the intercepted liquid by each one of the intercepting tools and the respective coefficient of variation (CV) has been always less than 10%. The repeatability of the results allows to evaluate in a positive way the reliability of the patternator.
The intercepting tools n. 14, 15, 16, respectively placed at 4450 mm, 4700 mm e 4950 mm from the ground, have not collected any amount of liquid. Probably this result is caused by the little sprayer fan capacity, that is not able to produce a suitable air flow (Fig. 7).
Fig. 8 shows the projection of air velocity vectors on a single vertical plane passing through the afore mentioned measure points, placed at different heights from the ground.
Referring to the measure points placed in front of the patternator, you can see that the horizontal velocity components allow the air flow to cross the patternator as far as an height from the ground of about 3500 mm.
The horizontal velocity component is greatly lower than the vertical one for heights more than 3500 mm. In that position, the most amount of the wet air flow is diverged upward and only a few quantity of it crosses the patternator. Owing to this the highest intercepting tools (n. 14, 15, 16) did not collected any amount of water during the tests carried out.
The analysis of the air velocity vector measured behind the patternator confirms this behaviour of the air flow.

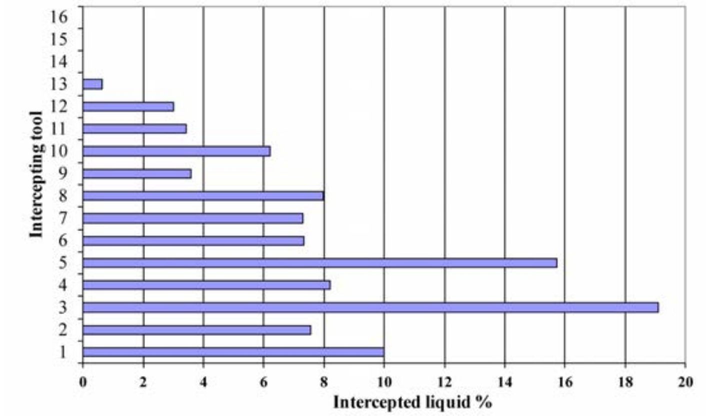

Fig. 7. Intercepted liquid percentage in each one of the intercepting tools.

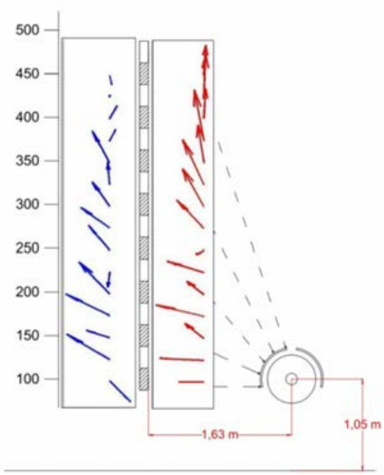

Fig. 8. Projection of air velocity vectors on a single vertical plane passing through the measure points.

Considerations and conclusions

The fulfilment of a test bench suitable for the adjustment of the sprayer machines employed for treatments in expanded canopy fruit-growing has required a closely study with the aim at the evaluation of the technical solutions which both assure the efficiency of the equipment and optimize its functionality.

On the ground of the obtained results, the patternator is suitable for the evaluation of the transverse patterns of distribution produced by sprayers at present used for treatments to tree cultures 3.5 m high.

Furthermore during the tests carried out all the manifolds and pipe drain have collected the liquid from the respective intercepting tools without any overflow.

The obtain results can also be satisfactory referring to the efficiency of the patternator E_c and the quality of the transverse distribution diagrams.

Other sprayer machines equipped with more capacity fan than the proved one will be tested in order to evaluate the intercepting functionality of the patternator at height more than 3500 mm. If also with these machines there will be not any amount of liquid collected by the highest intercepting tools, as occurred in the present tests, it will be necessary to design again their shape and sizes.

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Implementation of SUD in the Czech Republic – right or wrong way for inspection of pesticide application equipment?

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Summary

On the November 29th 2009 was issued new Directive no. 128/2009/EC by the European Commission. This Directive establishes rules for carrying out regular inspection of pesticide application equipment (PAE) in use. Article no. 8 of the directive states that the interval between inspections shall not exceed five years until 2020 and shall not exceed three years thereafter.

The inspection system was established in 1997 as obligatory in the Czech Republic. The system was built into a functional and efficient during this time and can be compared with systems in other EU member states. The inspection interval is three years for included groups of PAE and meets the current requirements for inspection now.

Introduction

By 14th 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.

New PAE shall be inspected at least once within a period of five years after purchase.

Some experts from several NGOs in CZ are of the opinion that it is necessary to satisfy the farmers and enable them to be able to get the PAE in use to inspection at intervals corresponding with the directive – it means **5 years!?** This will have negative effects for the network of approved inspection sites – reduce the number of inspections, reduced the number of stations, lower availability for farmers. The most significant impact of this change may have on the quality of PPP application which is inconsistent with the requirements for environmental protection.

Situation in 2011

Inspection is in good conditions, workshops carried out inspections and was prepared on-line database for evidence of inspected PAE. The interval was three years for every groups of PAE which were a subject of inspection (field sprayers, orchard sprayers, seed treatment machines, aerial application equipment and equipment for railway).

There have been reported further efforts from NGOs to extend the interval of inspection to five years for every groups of PAE.

Situation in 2012 and for the future

There was issued a new amendment 384/2011 Coll. which changed the inspection interval to five years! New (next amendment) is under preparation and wait for approved by the government. No certification system designed the verification of inspection will be establish.

Conclusions

- negative effects for the network of approved sites
- reduce a number of inspections,
- reduce number of sites,
- lower availability for farmers.
- the most significant impact of this change is expected on the quality of PPP application which is consistent with the requirements for environmental procection.
- the introduction of the longest interval of the inspection will have a negative impact on posibility of mutual recognition of inspections.

Outlook of the inspection of sprayers in Province of Trento

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Summary

Mountain landscape is the environment of agriculture in Trentino. Most of the hectarage is of high quality products like apples (11,500 hectares), grapes (10,000 hectares) and lesser extent small fruits and vegetables. There is a strong co-operative spirit, and many activities are conducted in partnership form. APOT (Association of Fruit and Vegetable Producers in Trentino) is a second degree Producers' Organization of about 10,000 farms. Average size of farms is 1.5 hectares and, as a form of income integration, part-time model characterizes about 50% of them.

Many housing districts are placed in sparsely among apple orchards and vineyards. Due to this condition the rural population has become more and more sensitive to issues related to spray drift. About 8,000 sprayers are in use on orchards and vineyards.

To achieve a better efficacy of treatments and rationalize use of chemicals, APOT in accordance with the local Government has decided to start the inspection activity since 1997. In addition a calibration of sprayer is made on the basis of farm orchards characteristics. Using two mobile test stations until now nearly 10,000 checks have been carried out (many sprayers have been checked twice or more). In compliance with Directive 2009/128/CE will also be organized activities for the control of sprayers used for weed control on localized application and for those in minor crops. ENAMA Guidelines have recently been made available and inspection activity is going on in close harmony with recommendations of ENAMA Working Group for national coordination on inspection activity.

Introduction

Trentino-Alto Adige/Südtirol is a Region in the North East of Italy, located in the mountain area south of the Alps. It is made by the two autonomous Provinces of Trento and Bolzano (Fig. 1). The territory is mainly mountainous and woodlands occupy more than 50% of it.

Agriculture is an important industry and is particularly specialized in the production of apples and wine grapes; in higher areas, livestock is still the most important activity and in some valleys the main production is small fruits (strawberry, raspberry, currant, cranberry) and arable crops (cereals, potatoes, vegetables, etc.).

In particular the production of apples is very important both for the quantity produced (70% of National and 15% of European production) and for the quality related to the vocation of growing environments.

With regard to the Province of Trento the apple orchard surface is about 11,500 hectares while the vineyards are about 10,000 hectares. There is a strong co-operative spirit, and many activities are conducted in partnership form. APOT (Association of Fruit and Vegetable Producers in Trentino) is a second degree Producers' Organization of about 10,000 farms. Today APOT consists of three consortiums: Melinda, La Trentina and Sant'Orsola.

The population of the Province is about 529,500 residents on 217 municipalities. Many housing districts are placed in sparsely among apple orchards and vineyards. Due to this condition the rural population has become more and more sensitive to issues related to spray drift.

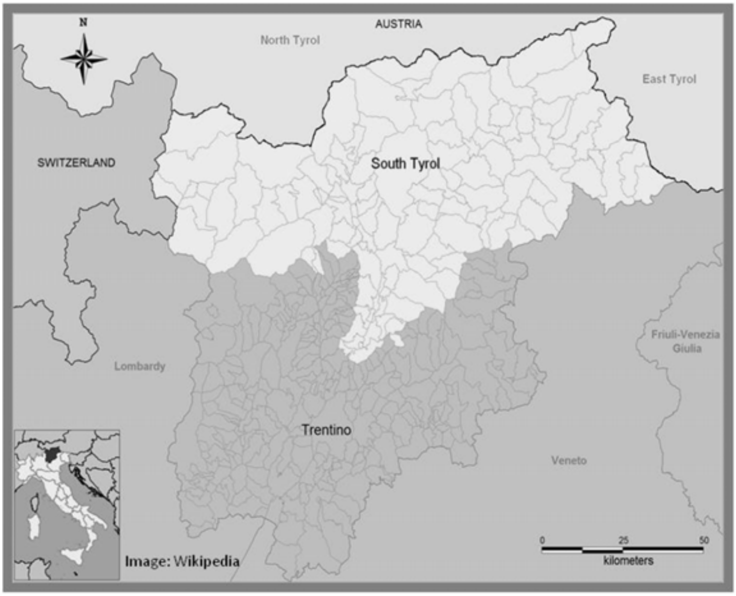

Fig. 1. Map of the two autonomous Provinces of the Region Trentino-Alto Adige/Südtirol.

Sprayers in use: types and characteristics

In the last twenty years, fruit growing has become more specialized with plantings of about 3 to 3.5 m between rows and trees 70-100 cm spaced from one other, using dwarfing rootstocks. Where possible orchards and vineyards have been mechanized even on slopes.
In this context, sprayer's requirements are different than in the past: the trend is to pass from standard axial fan sprayers towards tower sprayers and application volumes of 300-500 liters per hectare; in recent years anti-drift devices like anti-drift nozzles and airflow exclusion screens on one side of the sprayer are also taken into account on upgrading.
Very small farms lead growers to have a high number of sprayers in use (it is estimated in about 8,000 units, including those used in viticulture). These are often underutilized and in general medium to good condition.
In addition, the autonomous Province of Trento (PAT), with the Rural Development Plan 2007-2013, is also funding the Initiative No. 121 for the purchase of anti-drift sprayers equipped with devices to enhance the protection of the environment and human health.
In smaller farms knapsack sprayers are adopted for localized applications of herbicides, otherwise in bigger ones, there are combined equipments with mulching or small booms with one or two nozzles. Farms of minor crops like small fruits, vegetables and cereals use various plant protection equipments (handheld lances or guns, mist blowers, cannon sprayers, etc.).

Inspection of sprayers in use and calibration activities

Since 1997 the PAT in agreement with APOT and Advisory Service for agriculture (CTT–FEM) has decided to start the inspection and adjustment of sprayers in use. Two mobile centers with automated data collection were bought by the PAT and assigned free of charge to APOT management service. In 2010 the two centers have been replaced with two other, always of the same type, purchased directly by APOT. The inspection activity was entrusted to a company of mechanics. Recently, these mechanics were officially enabled with specific course. Initially, two technicians were working for the center, while today the activity is performed by a single operator. Itinerant inspections are carried out at fruit cooperatives by a truck equipped with spare parts: technicians can replace worn or not working parts.
In recent years the cost of the service requested by the company responsible, payable by the farmer or, in some cases, by the Organization of Fruit Growers is around 80 € per inspection. The cost of spare parts is always paid by the farmer. It is important to remark once more that the inspection service company uses for free the inspection tools.

It should be pointed out that APOT since 1999 has included the requirement of inspections in the Scheme for Integrated Production, with intervals of 6 years. This Scheme was then certified ISO 9001 since 2006 with inspection interval of 5 years.
APOT, through the individual cooperatives, has always monitored and managed the inspection activity: the schedule of checks is drawn up each year to ensure the regular activity of inspection within the time prescribed. In this way, each center works regularly throughout the season from March to September. At present sprayers in use, if not replaced, are at the third round of inspection. The Fig. 2 shows the trend of the controlled sprayers over the years in the Valleys of the River Noce (Associate Producers of Melinda), which represents, with 6,400 ha of orchards, the main productive area of the Province.

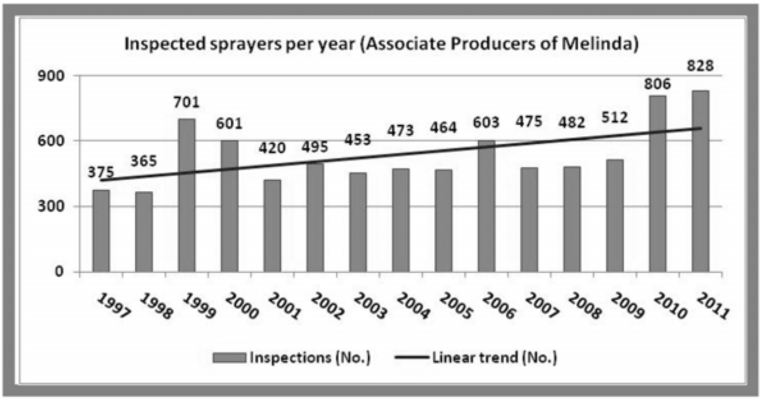

Fig. 2. Controlled sprayers in the Valleys of the River Noce (Associate Producers of Melinda) up to 2011.

The inspection consists of visual checks on the general feature of sprayers (pipes, filters, pump etc.) followed by instrumental measurements with particular reference to the nozzle flow rate, manometer precision and vertical distribution homogeneity (Fig. 3). Farmers will then receive a printed report containing sprayer measured parameters and calibration in terms of relative speed gear and engine speed, nozzle type, number and working pressure, according with orchard characteristics. At the end of inspection and calibration procedures the sprayer is marked with a sticker which is printed and distributed by APOT, indicating that the inspection has been passed successfully.
The software currently used is the one provided by the supplier of the inspection equipment. It needs a set-up with regard to controls and their acceptable limits provided from specific documents produced by the National Working Group of ENAMA.
Until today the wine industry, has worked on a more bland inspection activity. In the wine sector a part of sprayers, in recent years, have been checked with the mobile centers operating in the fruit industry and a regularly accredited private workshop is currently operating. During 2011 were checked 250 sprayers. Moreover it is ongoing a monitoring activity to quantify the number of equipments for herbicide application and sprayers used only in small fruits. Then it will be necessary to organize as soon as possible an inspection schedule also for these checks, and more in general, for all sprayers for which inspection is mandatory according to Directive 2009/128/EC.

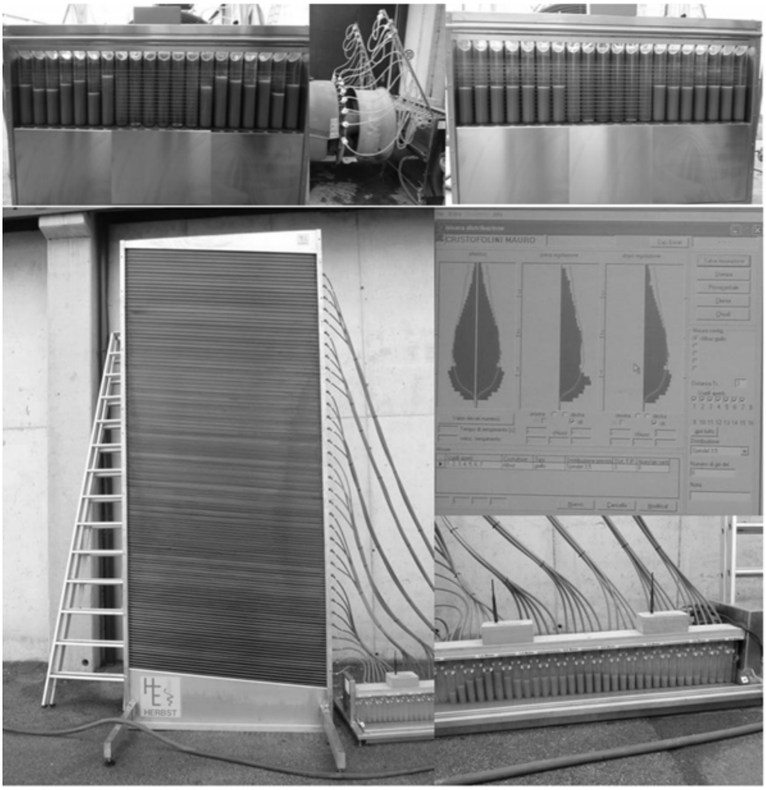

Fig. 3. Instrumental measurement of the nozzle flow rate and vertical distribution homogeneity during inspection and calibration activity.

Critical points to accomplish the obligations of the directive 2009/128/EC

The institutional bodies of Province, regarding the provisions of the dir. 2009/128/EC for the inspection of equipment in use, are going to develop the official resolutions of the service activation: implementation of ENAMA National Guidelines, recognition of authorized inspection centers and qualified inspectors, establishment of the monitoring committee for the centers and their activities, organization of monitoring. The National Action Plans, which should be available by the second half of 2012, will specify certain requirements.

It will be necessary also to quantify the amount of sprayers in use in fields other than the fruit/vine growing in order to organize inspections with an adequate number of centers and qualified personnel. Certainly the experience gained to date will facilitate this task.

Particular attention should be given to the adjustment of sprayers where fruit and vine growing is made by the same grower, as the calibration parameters adopted on vertical growing systems are not useful in other training styles (e.g. inclined trellising on Pergola vineyards).

Moreover the adaptation of the software for inspection checks and collection of data is necessary as required by in the ENAMA Guidelines.

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Portuguese sprayers inspections: issues to overcome

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Summary

The EN 13790 and agricultural products certification standards stimulated the sprayers inspections in a yearly basis in Portugal. Since 2006 *Centro Operativo e Tecnológico Hortofrutícola Nacional (COTHN)* inspected almost 3000 sprayers throughout the all country, including field crops sprayers, air assisted sprayers for bush and tree crops and a few hand held sprayers for greenhouse crops. In 2009 and 2010, Ambi3Q and A.CANO began with sprayers inspections in the north and south of Portugal, respectively.

The implementation of the article 8 of the European Directive CE 128/09 in all member states is an important step to minimize environmental impacts, protect human health and improve plant protection efficacy. However it is not an easy task due to the characteristics of agriculture and sprayers in use of each country.

The actual legislation concerning the construction and inspection of sprayers was published in the last 3 years. According to the article 8 of the European Directive, the Official Service *Direcção-Geral de Agricultura e Desenvolvimento Rural (DGADR)* of the Agriculture Ministry, developed the Portuguese law *Decreto-Lei n.º 86/2010 de 15 de Julho*, in 2010, to impose that mounted sprayers, trailed sprayers and self-propelled sprayers must be inspected and approved before 26 November, 2016.

The sprayers inspections carried out in Portugal should be an important tool to assess the sprayers in use and decide the best action plan to implement the article 8. Despite the sprayers inspections had been done mostly as a consequence of the European and National market rules, and so, the data collected are a rough sample of the real Portuguese situation, it is possible to observe that only one-third, of the sprayers inspected until now, have less than 5 years old. This means that the majority of the sprayers may not be in accordance with the standards and the article 8 of the European Directive.

Introduction

Since 2006 that *Centro Operativo e Tecnológico Hortofrutícola Nacional (COTHN)* has been inspecting sprayers through all country as a consequence of the European and National market rules. *COTHN* started sprayers inspections with orchard sprayers and later field crop sprayers (Nunes, 2010). During the first four years of inspections COTHN inspections focused mainly west of Portugal (orchards and vegetable crops), central Portugal (vegetable crops) and south coast of Portugal (vegetable crops and berries fruits).

The data collected during the sprayer inspections in the first four years revealed the first picture and the common damages in orchard sprayers and in field crop sprayers. These reports are important to achieve the best way of implementing the European Directive of sustainable use of pesticides.

The article 8 of the European Directive is an important step to minimize environmental impacts, protect human health and improve plant protection efficacy. That is three important reasons to make all efforts between farmers, technicians, organizations, manufactures and the Official Services.

Material and methods

The data collected during the four years period 2006-2009 was the base to achieve the results presented in these report. During the inspections the flow rate was checked and compared with nozzle manufactures tables as well as pressure gauges.

Although the majority of the sprayers inspections were based in orchard sprayers, field crop sprayers had a considerable representation especially in centre and south cost of Portugal (Fig. 1).

After colleting the data it was analysed and summarized in this report as well as the spatial distribution of the sprayers was used to produce the following maps (Fig. 1).

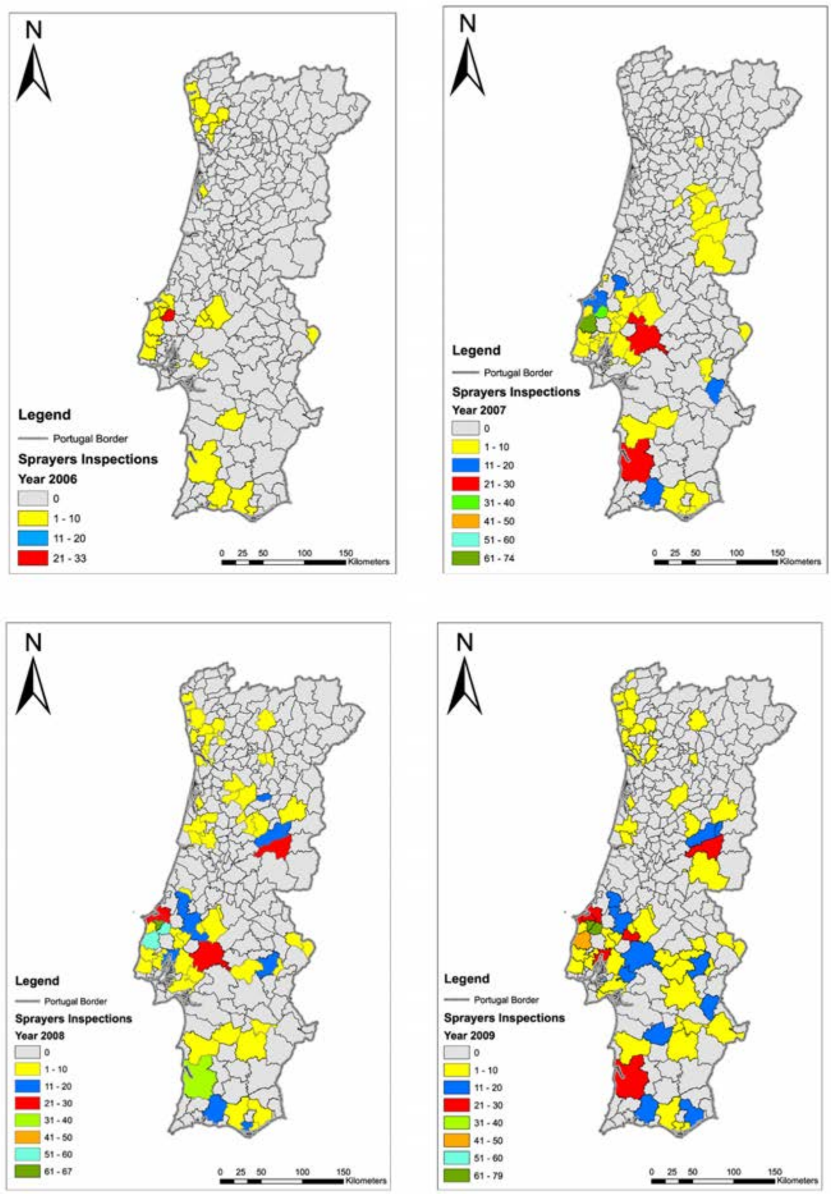

Fig. 1. Sprayers inspections made by COTHN in the four years period in Portuguese regions (Martins, 2006a), (Martins & Nunes, 2007b), (Nunes & Martins, 2008c), (Nunes & Martins, 2009).

Results

During the first four years the sprayers' inspections increased significantly. In 2006 COTHN inspected 134 sprayers, in 2007 increased to 430 sprayers inspected, in 2008 were 718 sprayers inspected and in 2009 were inspected 799 sprayers which represent in the four years 2081 sprayers inspections (Fig. 1).

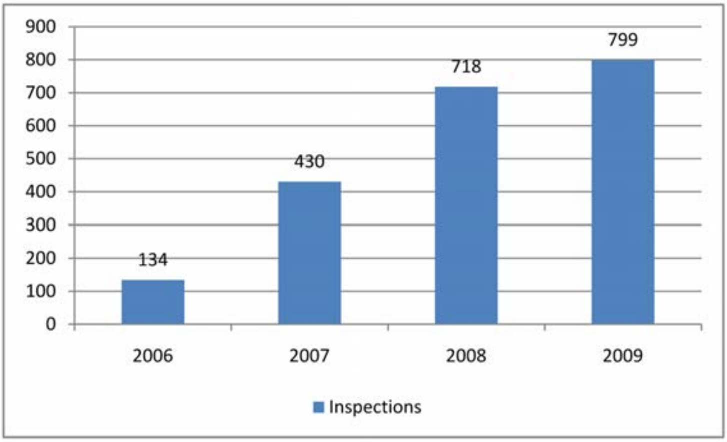

Fig. 2. Progress of certificated sprayers inspections by COTHN in Portugal (Martins, 2006), (Martins & Nunes, 2007), (Nunes & Martins, 2008), (Nunes & Martins, 2009).

The sprayers inspected during these four years are mainly for GlobalGAP and national markets requisites. Mainly, those requisites represent more than 60% of the total sprayers inspected until 2009; the other 40% could represent the voluntary sprayers inspected (Fig. 3).
Another important issue, is that sprayers in use could not be in accordance with the most recent legislation, because they were constructed based in older legislation, and therefore the sprayers could need reparation before sprayers inspections to be in accordance with article 8 of the European Directive.

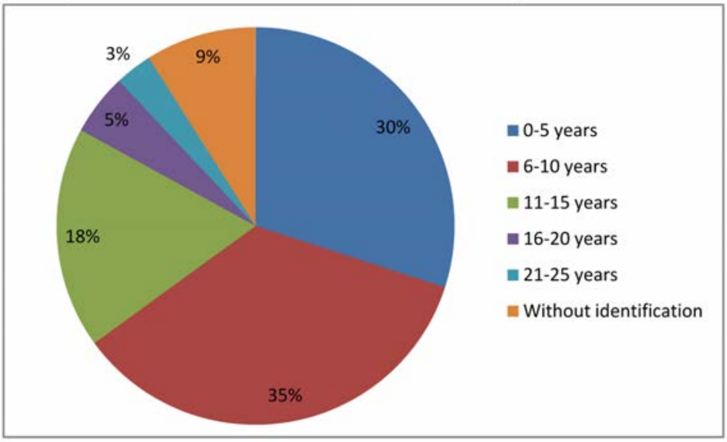

Fig. 3. Sprayers grouped in classes of age (Nunes & Martins, 2009).

The inspection of orchard sprayers continue to be, since the beginning, the main requests for inspections during these four years as the graphic show, 59% are orchard sprayers, 25% are boom sprayers an 9% are spray guns (Fig. 4).

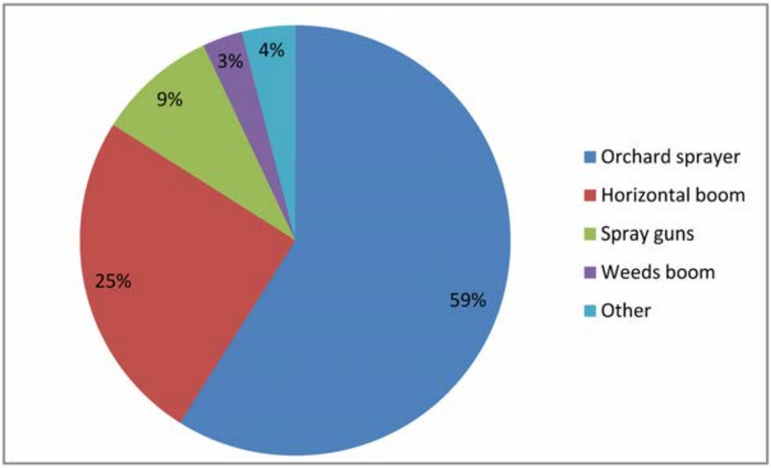

Fig. 4. Type of inspected sprayers (Martins & Nunes, 2007).

In sprayers inspections was checked the PTO shaft drive and the power input connection to ensure the operator safety. Nearly 40% of the PTO shaft drives were not protected and exposed the moving parts, which is a significant percentage, considering the danger in which farmers are daily working. The others 60% of the PTO shaft drives were protected.

Another relevant information is the working pressure used in pesticide applications in orchard sprayers. The working pressure amplitude is big which varies between 5 bar and 35 bar. Higher working pressures are more common in sprayers equipped with adjustable hydraulic nozzles and lower pressures more common in sprayers equipped with hollow cone nozzles or Albuz ATR nozzles. It is possible that sprayers and sprayers fans are not well dimensioned to orchards, because of the need to project the pesticides to the biological target (Fig. 5).

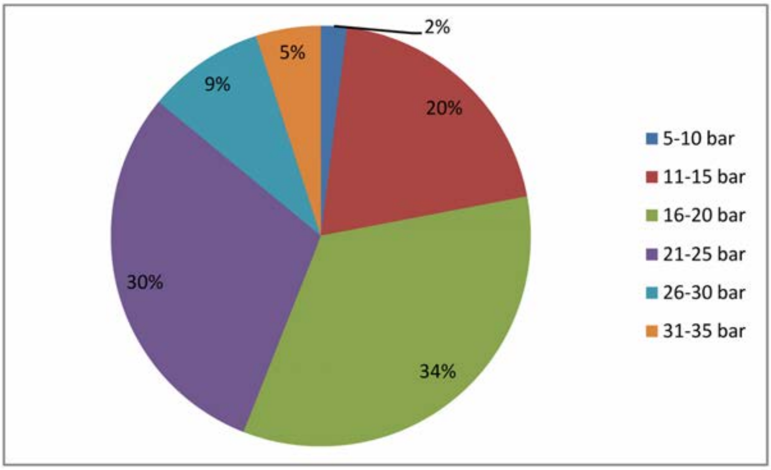

Fig. 5. Working pressures most used in orchard sprayers (Martins & Nunes, 2007).

In field crop sprayers the working pressure are still higher as the Fig. 6 shows, the majority of farmers are using working pressures above 10 bar, which is an important issue to increase drift in pesticide application. Only one third of the farmers, which had inspected their sprayers with COTHN, confirmed that the working pressures used were below 5 bar (Fig. 6).

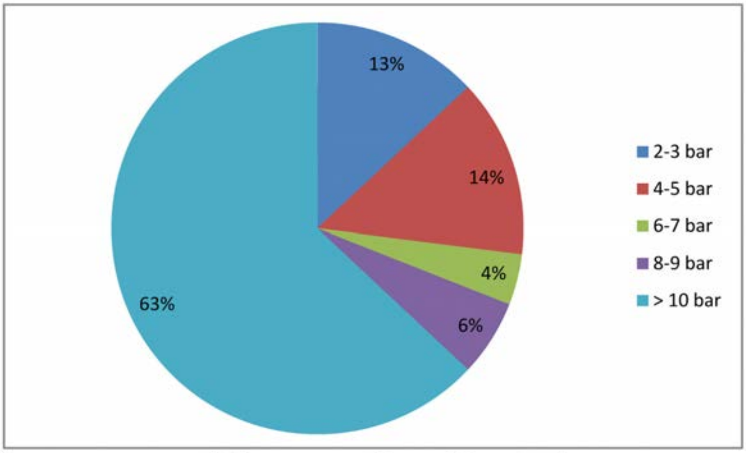

Fig. 6. Working pressures most used in boom sprayers (Martins & Nunes, 2007).

In Portugal sprayers are mainly from Portuguese manufactures, they represent 73% of the sprayers inspected. Tomix and Rocha are the Portuguese manufactures leaders with 31% and 29% respectively. Only Ilemo-Hardi is the international sprayer with more expression in Portugal with 9% of the sprayers inspected and the remaining 18% are represented by international manufacturers like Progroup, Caffini, Berthoud, Munckhof, among other (Fig. 7).

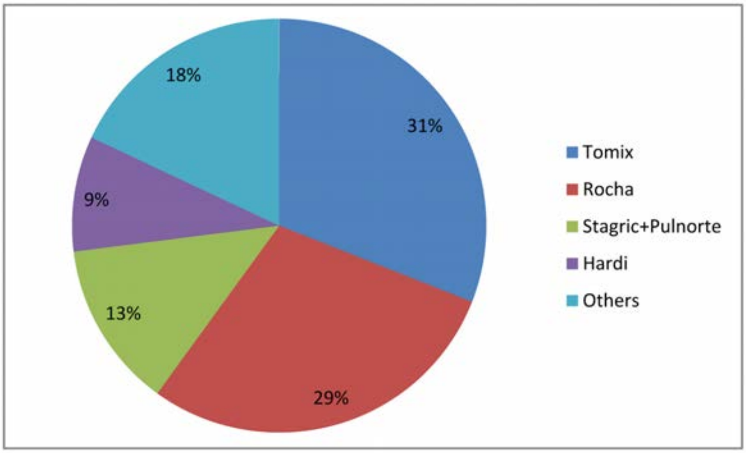

Fig. 7. Most used sprayers divided into manufactures (Nunes & Martins, 2009).

The anti-drip valve system is an important tool to protect environment and limit leakages after spraying had been stopped. The EN 13790, the European Directive 2009/128/CE and Portuguese law impose that this system must function well. According to the results of sprayers inspections there are still 39% of working sprayers without anti-drip valve system (Fig. 8). This is one of the aspects that sprayers must repair before sprayers inspections according with the article 8 of the European Directive.

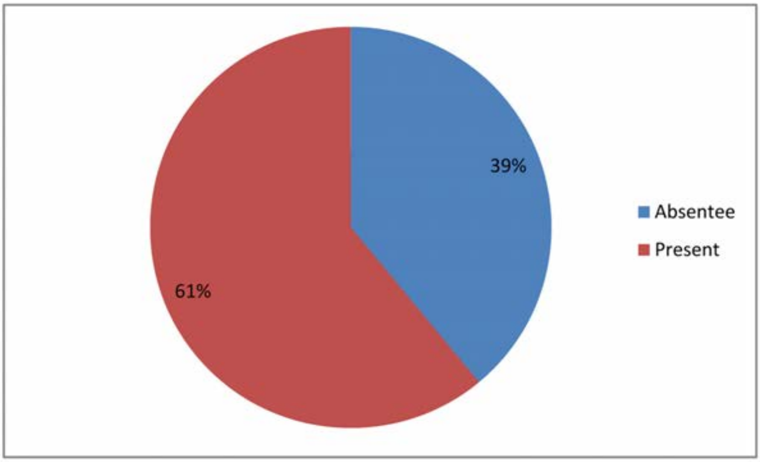

Fig. 8. Anti-drip valve system in inspected sprayers (Martins & Nunes, 2007).

Orchard sprayers had 50% of the pressure gauge with defects and field crop sprayers had 36% with defects. When the defects of the pressure gauges are higher like the Fig. 9 shows, it could represent wrong calculations to determine the correct dose of pesticide to apply in the biological target.

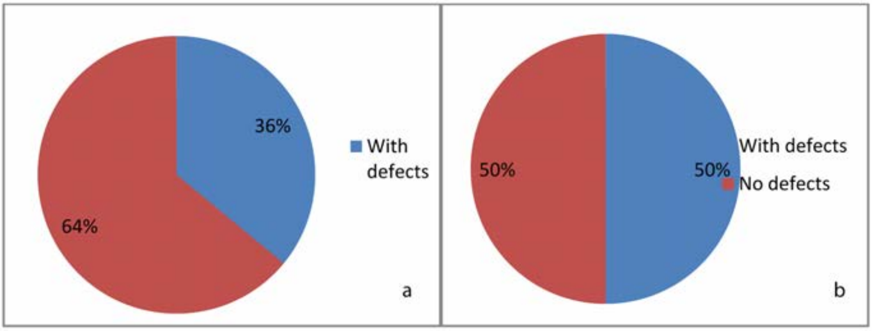

Fig. 9. Defects in pressure gauges of field crop sprayers (Martins & Nunes, 2007a), defects in pressure gauges of orchard sprayers (Martins & Nunes, 2007b).

The sprayers inspections have the possibility to show farmers the flow rate of the nozzles in use, and it illustrates that more than 50% of the nozzles are not working right leading to bad pesticide application. According with Fig. 10, 31% of the nozzles inspected are deteriorated and 15% were obstructed, confirming that the flow rate of those nozzles was not according with manufactures tables. The adjustable hydraulic nozzles are still preferred by 8% of the farmers, which had, their sprayers inspected by COTHN (Fig. 9).

The use of adjustable hydraulic nozzles are important to farmers because they could adjust the hollow cone and the flow rate to each situation, even the distribution are not respected. Most of the adjustable hydraulic nozzles inspected presented differences between the symmetric nozzle, which could present bad distributions of the pesticide in orchards (Moreira, 2006).

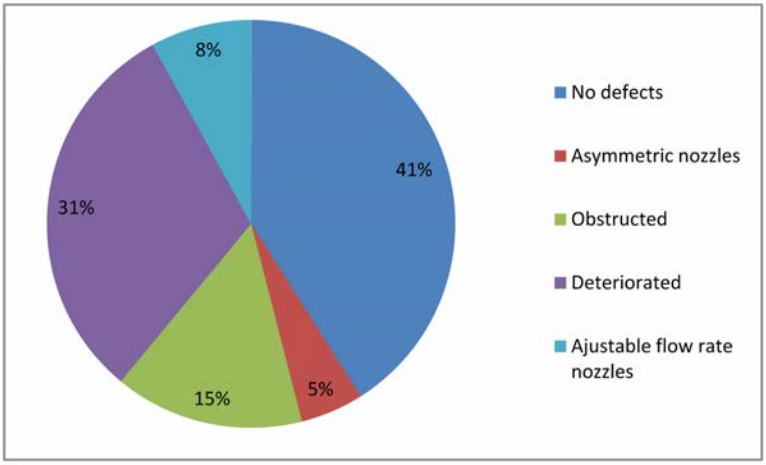

Fig. 10. Most common defects in nozzles (Martins & Nunes, 2007).

The majority of the pumps had no significant defects according to the 84% of the inspected sprayers, but 72% did not have the proper air pressure in the pneumatic pressure pulsation damper resulting in pulsations of spraying liquid as well the 9% which needed to replace the damper membrane. There were 18% of the pumps, which required to be repaired, and 1% had leakages (Fig. 11).

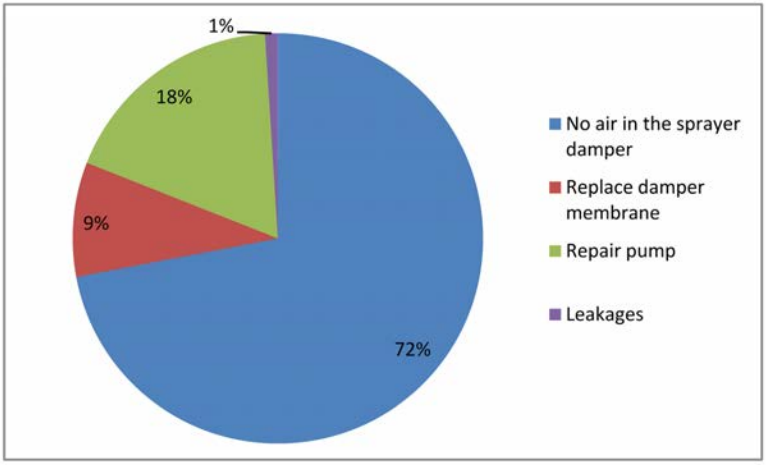

Fig. 11. Most common defects in pumps (Martins & Nunes, 2007).

According with the 60% of the sprayers inspected (Fig. 12), farmers does not pay attention to clean the pump suction filter as well as the pressure system filter which leads to differences of pressure on both sides of the sprayer and differences of the flow rate of the nozzles. In 21% of the sprayers they had to replace the filter, because it was damaged and was not working well and in 13% the sprayers had no pressure system filter.

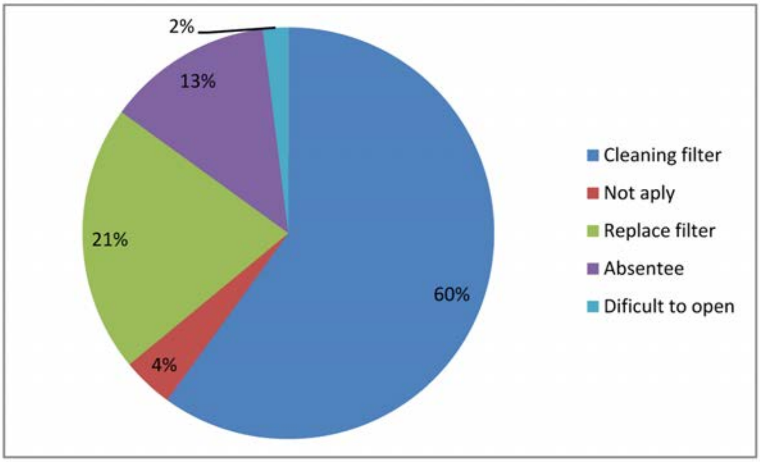

Fig. 12. Most common defects in filters and an example of pump suction filter (MARTINS & NUNES, 2007).

In 42% of the sprayers inspected the pipes system was deteriorated, needing substitution, 33% had differences in the internal diameters of the pipes, which interfere in the pressure at which nozzles are working and 25% of the pipes, had leakages.
The rinse tank is important to clean the internal system of sprayer after the pesticide application, however it is only present in 51% of the sprayers inspected.

Conclusions

During the four years of sprayers inspections was found that the low accuracy of the pressure gauges used, the nozzles deterioration and low uniformity of the distribution can be decisive in the success of the application and amplify serious doubts in the efficiency of the pesticides usage.
It is therefore important to use strategies to motivate farmers to reduce their mistakes in pesticides application, promoting calibration and maintenance of the sprayers to reach the objectives for a safer agriculture in the use of pesticides.

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Proposal of an inspection methodology for pneumatic drills

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Summary

In recent years the contribution of pneumatic drills to the dispersion in the environment of insecticides particles derived from the abrasion of dressed seeds has been studied and different devices aimed at reducing the dust drift have been proposed. The European Directive 128/09 on the sustainable use of pesticides aims to achieve a more sustainable use of pesticides and introduces the compulsory inspection of equipment for pesticide application.
At the present time, an official methodology to inspect both new and in use drills and the effectiveness of drift reducing devices is still lacking. The aim of the paper is to present a simplified methodology that can be applied to periodical inspection of the above mentioned equipment. Such a methodology has been elaborated basing on the results of a three-year activity, carried out at CRA-ING within the APENET research project.

Introduction

The article 8 of the European Directive 128/09 is related to the inspection of equipment in use and it stated that "Member States shall ensure that pesticide application equipment in professional use shall be subject to inspections at regular intervals". The pneumatic drills sowing dressed seed are not directly included in this group of machines even if they distribute a certain dose of pesticide associated with the seeds in the soil. Moreover it is ascertained that they release a part of the applied pesticides in the environment as dust losses (Greatti et *al*., 2006; Pochi et *al*., 2011). At the moment, the inspection methodologies are available for a limited number of equipment, namely the sprayers (equipment for application of liquid products); for other equipment (as duster, foggers, granules applicators, seed treatment equipment, mist blowers/generators, wipers) the inspection methodologies are lacking (Harasta and Polvêche, 2009).
An inspection methodology is generally derived from a certification method for new models and represents a chain of controls and inspections aimed at restoring the initial functionality of the machines, within a given level of tolerance. As to the dispersion of active ingredients by using new pneumatic drills, some countries adopt methods with national valence (Rautmann et *al*., 2009) but certification methods recognized as international standard do not exist.
In this work, the pneumatic drills are taken into consideration as distributors of dressed seeds and granular products, contributing in such functions, to the dispersion of chemical products in the environment. Basing on a test method developed at CRA-ING during the APENET Research Project (Apenet, 2011) for the study of abrasion dust emissions during the sowing of maize seed dressed with insecticides, this paper proposes some ideas for a simplified approach to the inspection of the pneumatic drills in use, from the point of view of the containment of the dispersion of active ingredients during the sowing.
A methodology based on static tests was developed in order to obtain reproducible test conditions and comparable results. It is based on the sowing simulation of the of maize seed under artificial wind conditions (Fig. 1). The seeder was operated "*sur place*" by means of electric engines allowing to exactly reproduce the speed of the driving wheel (virtual working speed) and of the vacuum fan (depression value) and distributed seed dressed with insecticides. The active ingredients were detected at ground level and in the air by means, respectively, of a series of Petri dishes (with a water-acetonitrile solution) and air samplers with PTFE membrane filters placed at five sampling distances. The chemical analyses of the samples revealed the chemical residues at ground and the concentrations in the air. The method has been used for assessing the efficiency of devices applied to the seeder, aimed at the drift reduction, in comparison with the emissions of the conventional machine (i.e. the same drill without deflectors). Through a data processing method, from the data provided by these static tests it is possible to foresee the field active ingredients dispersion that would occur under similar atmospheric and operative conditions (Biocca et *al*., 2011).

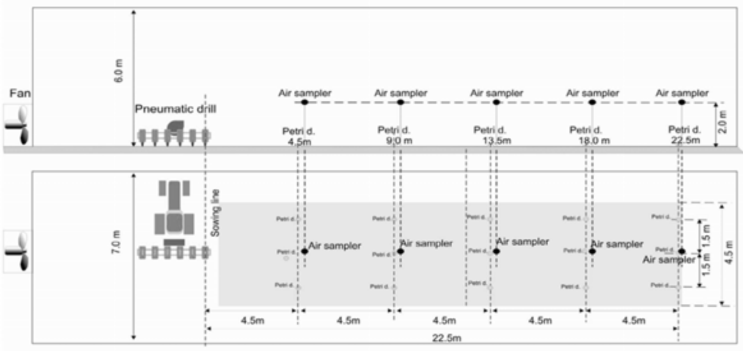

Fig. 1. The layout of CRA-ING testing area for checking pneumatic drills.

Results

The method provides accurate description of the behaviors of dust drift at ground and in the air, allowing precise evaluation of the reduction obtainable with the devices for the reduction of dust dispersion and it could be adopted for certifying the characteristics of new machines. This method can be a starting point for an inspection methodology for pneumatic drills in use. For this purpose, the methodology could be suitably simplified in order to: 1) avoid long and expensive analytical procedures; 2) avoid the risk of operator exposure to the active ingredients during the tests. In order to produce this methodology the following steps are needed.

1) References for the evaluation of the performances of pneumatic drills in use – Since the study aims at defining the criteria for the evaluation of pneumatic drills in use from the point of view of the dispersion of pesticides contained in the abrasion dust, conventional machines cannot be considered, because they are not planned for the reduction of dust dispersion. For each model of drill in use, the reference should be theoretically represented by a new drill of the same model, equipped by the manufacturer with air deflectors (commonly used in several countries for reducing dust dispersion) or other devices. Such a new equipment, should be tested and certified as regards dust/active ingredient emissions, according to a reliable methodology developed on purpose. The values observed in the new machine should be restored in the periodical controls on the machines in use. In practice, this goal could be difficult to achieve in some cases, i.e old machines no more present in the market. A possible alternative consists of the introduction, as a reference, of minimum requirements common to all machines, like levels of dust/active ingredient emissions, that should have been proved to be innocuous for the bees in tests on different new machines.

2) Test methodology for new machines – The above described method is based on static tests and, because of its reliability, reproducibility and accuracy, it seems to be suitable for testing new machines. The evidenced necessity of simplifying the analytical phase and of reducing the risk of exposure could be achieved by using seed dressed with a non-toxic and easily-detectable tracer. An essential point is that the seed should be dressed similarly to commercial seed, in order to have results referable to normal operating conditions. The results should be reported in terms of concentrations, both at ground and in the air. According to the considerations reported at the point 1, the results provided by the certification of the new machines will represent the reference values to be restored in the inspection activity of the machines in use.

3) Simple and reliable methodology for the inspection of pneumatic drills in use – If the criteria proposed in the points 1 and 2 are accepted, the certification data of new precision drills modified with air deflectors or other devices will represent the target of the periodical inspections during the lifetime of all copies of the same model. Although based on the same criteria of the methodology for new machines, the inspection methodology should be more simple and faster, providing results immediately referable to the target values. For instance, the number of samplings can be reduced to one or two distances, deemed as the most significant. The same tracer and analytical techniques proposed at the point 2 will help to speed up the procedure.

4) Sensitive points to be checked during the inspection of pneumatic drills in use - In addition to the presence and efficiency of the specific device for the reduction of the dispersion of dust during the sowing, there are different points through which the dust can be expelled and parts directly involved in the efficiency of the machines These parts (Fig. 2) should be checked periodically in order to maintain the drill efficiency. A possible list of such controls should include: 1) the status of the pipes of the pneumatic system of the drill; 2) the status of the gasket sealing the connection between the flange supporting the deflector pipes and the outlet opening of the vacuum fan; 3) the functionality of the pressure gauge (correct depression value help to limit dust dispersion).

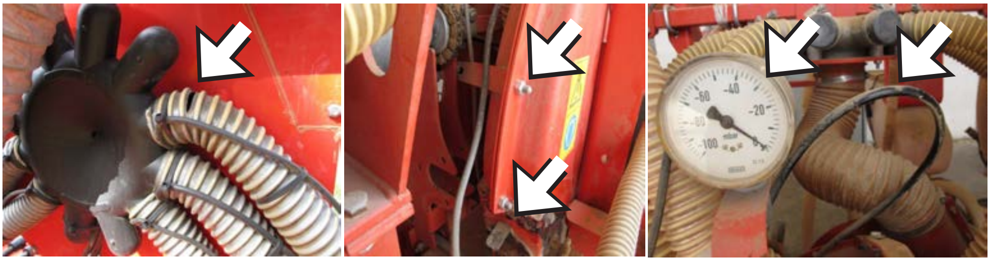

Fig. 2. Some sensitive points to be periodically checked in order to maintain the drill efficiency.

Conclusions

A test methodology for pneumatic drills in use was proposed. Such a proposal is based on static tests realized to verify the efficiency of drift reducing devices applied to new drills. A large scale application of a test methodology for machines in use will require to avoid long and expensive analytical procedures and the risk of operator exposure to the active ingredients during the tests. For this purpose it was proposed the use of seed dressed with a non-toxic and easily-detectable tracer during the test.
The inspection methodology should be more simple and faster, providing results immediately referable to the target values. An essential point is that the seed should be dressed similarly to commercial seed, in order to have results referable to normal operating conditions. The control activity will also concern the inspection of the most sensitive points of the pneumatic drill, from where dust amounts can be emitted, in order to verify their integrity and efficiency.

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Technical solutions to reduce drift of pesticides in apple orchards of Trentino

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Summary
Drift of pesticides is a critical element in achieving the plant protection management. As a phenomenon influenced by multiple factors is likely to be reduced, but not totally eliminated.
Actually in Province of Trento most growers who sprays next to drift sensitive areas (houses, roads, bicycle patches, etc.) use mainly spray lances. To mitigate drift many other technologies are available along with several techniques. On the other hand the differences between training and pruning systems, planting distances, cultivation environments, etc., must be taken into consideration to achieve the highest level of reduction. The main characteristics of the rural landscape of Trentino are: strict connection with inhabited areas, medium or steep slope of most apple plots and intensive orchard growing with height of trees up to four meters.
Comparative tests have been carried out in 2009 during different wind conditions (almost total absence and presence of wind) to verify the mitigation ability of anti-drift nozzles, used with different sprayer adjustments and coupled with other devices. Due to the instability of wind conditions during treatments, as to ensure the maximum level of drift reduction, other technical solutions were tested in 2011 and resulted adoptable together with the devices already tested.

Introduction
Drift of pesticides is a critical element in achieving the plant protection management. As a phenomenon influenced by multiple factors (Van Ee, 1998; Wolf, 2000) is likely to be reduced, but not totally eliminate. Actually in Province of Trento the most of growers who sprays next to drift sensitive areas (houses, roads, bicycle patches, etc.) uses spray lances. To mitigate drift many other technologies are available along with several techniques (Balsari et al., 2000; De Schampheleire et al., 2008; Herbst, A., 2005; Rautmann, D., 2003).
On the other hand the differences between training and pruning systems, planting distances, cultivation environments, etc., must be taken into consideration to achieve the highest level of reduction (Balsari & Marucco, 2004). The main characteristics of the rural landscape of Trentino are: strict connection with inhabited areas, medium or steep slope of most apple plots and intensive orchard growing with height of trees up to four meters.
Based on these considerations during the fruit season 2009 an experimental activity began on drift management in apple orchards. Comparative tests have been carried out during different wind conditions (almost total absence and presence of wind) to verify the mitigation ability of anti-drift nozzles, used with different sprayer adjustments and coupled with other devices. As the general impossibility to meet the requirements of ISO 22866 (Methods for field measurement of spray drift) an internal protocol was arranged and followed for measurement tests. As the drift measurements have been taken up to seven meters in height, eso and endo-drift indexes were generated showing the average value of the deposit found up to that height and at the respective sampling distance. Arose results showed that at first the most appropriate equipment to adopt in that growing contest appeared on-target sprayers with anti-drift air injector nozzles (Bondesan & Rizzi, 2010).
Due to the instability of wind conditions during treatments, as to ensure the maximum level of drift reduction, more tests were necessary to find other solutions adoptable together with the devices already tested. The first results of this recent comparative tests are presented and discussed in the following paragraphs.

Materials and methods
For that purpose different devices for the distribution of pesticides have been compared. The tested equipments were: a tower sprayer prepared with ATR swirl nozzles; the same sprayer equipped with anti-drift air injector nozzles (AVI) and a device for airflow exclusion by one side; a handheld gun sprayer model Nehro (Braglia) with manometer (Fig. 1).

Fig. 15. Equipments compared during the test: particular of the side flow exclusion device (right), the double crown of nozzles (left) activated indipendently and the handheld gun fitted with manometer (oval box).

The experimental activity took place in a Golden Delicious orchard, row distance of 3.4 m, hight of plants from about 2.0 m (fault replacements) up to 3.9 m.
Five rows were sprayed with a tracer solution of yellow tartrazine and Petri dishes were used to collect the ground deposit under the row and at different distances from the edge of the orchard up to 22 m.
The tower sprayer equipped with the side airflow exclusion device was used to spray the row of edge and the adjacent one only from the outside to the inside part of the orchard, avoiding the use of air and liquid flow directed out of the orchard. The same equipment arranged in the standard configuration (reference) and the spray gun were used to spray as in a standard application thus treating each side of the row.
The main working parameters and adjustments used during the trials are resumed in Tab. 1.
The presence of a double crown which allowed to activate independently each series of nozzles and the comparison of the diagrams obtained by a calibration on patternator with both types of nozzles suggested to operate with the same nozzle configurations described in the calibration report.
The average speed of the operator treating with the handheld equipment was determined during the experimental application while the liquid flow rate was determined at the end of the application as the average of five measurements.

Tab. 1. Working parameters and adjustments used during tests.

Equipment	Type and number of nozzles	Pressure (bar)	Nozzle flow rate (l min^{-1})	Operative speed (km h^{-1})
Tower sprayer + ATR orange	Swirl cone 6+6	7	1.17	5.3
Tower sprayer + AVI yellow + side flow exclusion	Flat fan air injection 5+5	8	1.31	5.3
Handheld lance (gun) + orifice ø1.5 mm	Metering disk 1+1	28	6.42 (average)	0.9 (average)

The tests were conducted under conditions of moderate wind (average speed of around 1.0 m/s) and light vegetation (Fig. 2). Three replicates for each tested equipment were carried out.

Fig. 2. Picture of vegetation of the experimantal orchard (row of edge).

Results

The average values of the three replicates are shown in Fig. 2. These results are expressed as the percentage of the sprayed volume (normalised values).

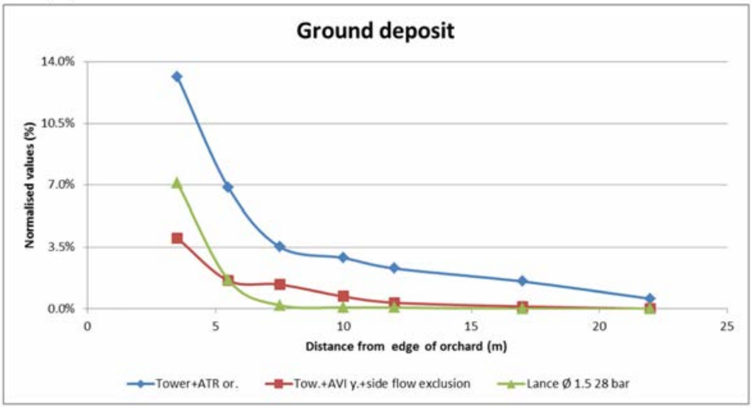

Fig. 3. Normalised values of ground deposit retrieved for each of the tested equipment (average values from three replicates).

Looking at the graphic is evident the mitigation ability on reducing the eso-drift both for the handheld gun and the tower sprayer with anti-drift devices in comparison with the reference equipment. The curve of the spray gun starts higher in the first meters above the row of edge and decrease more rapidly than the tower sprayer arranged in the anti-drift configuration (red curve). Moreover taking a look at the Tab. 2 it is possible to appreciate what happens in terms of increase/reduction when the ground deposit retrieved under the row and the eso-drift amount are refered to the real application volume. The difference between the very high application volume typical of the handheld equipments and the (adjusted) standard volume applied by the tower sprayer is mainly marked by the increase of ground losses under the trees.

Tab. 2. Comparison between drift reducing equipments and the reference sprayer equipped with swirl nozzles considering typical standard application volumes (tower sprayer 1,500 l/ha; handheld gun 2,500 l/ha)

Equipment	Tower ATR	Tower AVI + Side Flow Exclusion	Handheld lance
Eso-drift deposit	Reference	-76,4%	-67,8%
Under row deposit	Reference	-52,9%	+41,2%

Discussion

The factors that contribute to determine drift and its intensity are multiple and closely related one another. The behavior of the operator is essential for directing the success of treatment, finding the right balance to maximize the application efficiency and minimize losses.

This is easily accomplished with the adoption of technologies routinely used in the phytoiatric management of the orchard (air-carrier sprayers), as the operator can precisely adjust speed, pressure and spray application volume.

Equipping modern air-carrier sprayers with proper devices (tower conveyors, anti-drift nozzles, devices for airflow side exclusion or reduction, etc.) it seems to be possible to contain the dispersion of product much more than the handheld equipment.

Handheld sprayers – even if equipped with additional devices such as manometer – are not easily adjustable by the operator (Bjugstad & Skuterud, 2009). The performances of the handheld lance are spoiled by the high volume of application related to the impossibility of a precise calibration. This equipment proves to be more suitable as a tool for localized rescue applications or when mechanization is unrealizable, rather than as a real solution for reducing waste and drift.

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Testing device for a complex measurement of the performances nozzles

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Summary

The testing device for complex automatic measurements of agricultural nozzles (Fig.1), and some tests methods are presented. The developed methods provide information on the individual parameters of spraying quality of each studied nozzle. Results of those studies has been recorded in the electronic database, and then analyzed by means of a computer program which will also make it possible to eliminate faulty nozzles. Besides, results of the estimation for the nozzles considered to satisfy the requirements of the standards but examined on a 50 mm grooved table (according to the ISO standard 5681-1:1996) has been subjected to conversion to the requirements of the grooved table (100 mm). Differences results CV for virtual paternator and laboratory paternator tests were obtained: 0,4 to 3,1 percentage point.

Conversion of the results will be performed by of the prepared computer program and adopted to practically use sprayer booms of agricultural nozzles (virtual paternator). This program will also determine the sequence of placing the nozzles on the spray boom. Program environment "R" is used on conversion of results.

Key words: spraying quality, mandatory inspection, device to complex testing of agricultural nozzles.

Introduction

Agricultural nozzles are one of the working elements of the sprayer which (in some situation) can lead to wrong application of Plant Protection Products. Causes of wrong spraying quality of nozzles could be different: the wrong nozzle type, its wear-out as a result of a wrong or too long use, or a mechanical deformation of the spraying opening. A visual estimation of the spraying quality of the nozzle is limited and in fact possible only in case of extremely faulty operation. Therefore, different procedures and measuring device have been developed to estimate the spraying quality of the nozzle. But as the spraying quality could be characterized by different parameter, those procedures and devices allow only to determine on of these parameters.

One of the factors actually very important following our opinion is the good choice of the used nozzles, and also the parameters measured to evaluate the performances of this nozzles. The spraying quality of nozzles is characterized by such parameters as (Fig. 1): flow rate, individual pattern (spraying angle, coefficient of asymmetry) and transverse distribution under the boom (Coefficient of Variation - CV).

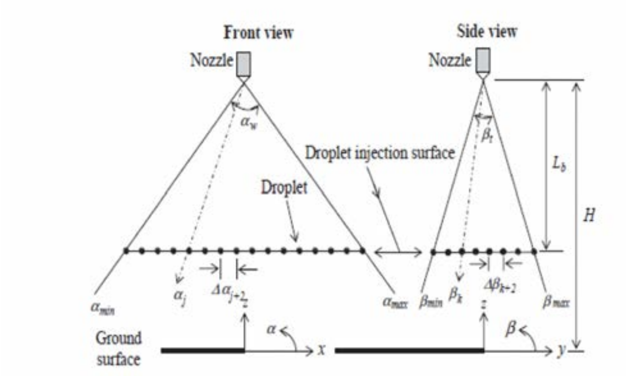

Fig. 1. Schematic showing the virtual nozzle with spray cloud boundaries, droplet injection surface, and droplet injection positions: x,y and z, coordinates; α and β angular coordinates defining the spray boundary and droplet positions; H, nozzle height above the ground, Lb liquid sheet break-up length. [Sidahmed and al., 2005].

Using nozzles presenting a poor spraying quality for the application of Plant Protection Products in agriculture increases the potential risks of the environment contamination and decreases the efficacy of the plant protection. At present, very complex, multi-sided activities are undertaken on the organizational and technological levels, which aim at applying pesticides in a precise way (tab. 1).

Tab.1. Main activity area in the mandatory periodic inspection of sprayers

Nr	Specification
1.	Keep standards for organizational factors principally connected with theoretical preparation (training) of the operator on the performance of pesticide treatments.
2.	Keep standards for technical factors, related to the improvement of the construction the technical state of the equipment for plant protection
3.	Keep standards for technological factors, related to the improvement and preservation the mandatory periodic inspection
4.	Keep standards about Integrated Quality Management Systems for technical sprayers control and process in plant protection on individual farm.

Studies on nozzles are conducted considering the requirements of ISO standard 5681-1:1996. However, it should be stressed that separate measuring devices are necessary to determine the different parameters of the nozzle spraying quality parameters [Sawa and al. 2001]. Moreover serious problem can make up of standards about Integrated Quality Management Systems for sprayers control process in Sprayers Control Station (SKO) and use sprayer to pesticides on farm. Therefore it was put some questions about control methods used sprayers (and nozzles) runes in closed rooms SKO and results of nozzles test useful in respect of time, see tab. 2.

Tab. 2. Characterization of the tests conditions of sprayers in SKO - questions

Specification questions	Measurement methods			
	Patternator (measurement unit CV)		Flow rate methods	
	Electronic	manual	spray booms	**Electronic device**
1. To measurement indispensable room is *(yes, no)*	yes	yes	no	no
2. Evaluate concerns measurement : ***(****spray or flow rate)*	spray	spray	Flow rate	Flow rate
3. Water to test is taken from reservoir of testing sprayer *(yes , no)*	yes	yes	no	no
4. Which individual pattern each single nozzles are measured	no	no	Flow rate	Flow rate
5. In time of measurement observed drift of sprayed liquid is • *(yes, no)*	yes	yes	~ no	~ no
6. Work of sprayers induce circulation of air about -speeds in range ***(m•s⁻¹)***	1 - 2 m/s	1 - 2 m/s	0	0
7. Work of sprayers induce out height of % moisture of air, in room from e.g. 67%	99,9%	99,9%	70%	68%
8. Work of sprayers in room with tempera-ture e.g. 18 ⁰C induce fall down of tempera-ture abort ⁰C	2 – 3 ⁰C	2 –3 ⁰C	~ no	~ no
9. Employee of service do they have direct contact with solution of sprayed liquid *(yes, no)*	yes	yes	no	no

Question from table 2 and some results of CRA-W Gembloux studies ([Debouche and al. 2000]) determine the base for project device and complex measurement performances of nozzles. The developed methods will provide information on the individual parameters of spraying quality of each studied nozzle. Results of those studies will be recorded in the electronic database, and then analyzed by means of a computer program which will also make it possible to eliminate faulty nozzles. Testing device (Fig. 2 and Fig. 3) and researches was done in UP Lublin, Poland. Validation of the developed methods of studies and the spraying process was performed in the Walloon Agricultural Research Centre – Gembloux, Belgium (CRA-W), which has an accredited laboratory (ISO 17 025, Certificate BELAC 266-T) for the nozzle spray pattern measurement.

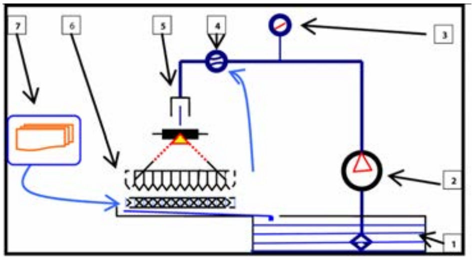

Fig. 2. Device to complex measurements of agricultural nozzles (schema)

1. Reservoir waters and filter of pump,
2. Pump in hydraulic arrangement,
3. Manometer,
4. Flow-meter
5. Nozzles container and telescopic liquid feeder system,
6. Groove table,
7. Measure (electronic) device with computer.

Fig. 3. Device to complex measurements of agricultural nozzles

- Grooved table with dimensions 2500 mm x 1000 mm with spacing grooves every 50 mm of wall height of 100 mm.
- Pump with single-phase 230 V power supply with a capacity exceeding 10 l / min and a maximum operating pressure of 12 bar.
- Industrial computer supports automatic nozzle testing equipment.

Aims and sphere of investigation

Realization of the project is aimed at developing a measuring device and methods that in laboratory conditions will ensure complex evaluation of the nozzles, and the obtained results and their characteristics will make it possible to determine the spraying quality of the spray boom of the sprayer with a great degree of probability for field conditions - ***virtual patternator.***
The methodology followed during the study is to determined and measured the performances of each single nozzles, registered these parameters in a database and finally enlarge by a computed processing the results and the conclusion under the whole boom. The basically measured parameters of each single nozzles are the flow rate and the individual spray pattern measured on a 50 mm grooved table (according 5681-1:1996).
The computed processing allows determining the transverse distribution of the whole spray boom under a virtual 100 mm grooved table. The process mace possible to determining the best sequence of placing the nozzle on the boom.
Programme environment "R" is used on conversion of results. The idea of conversion is presented in Fig. 4.

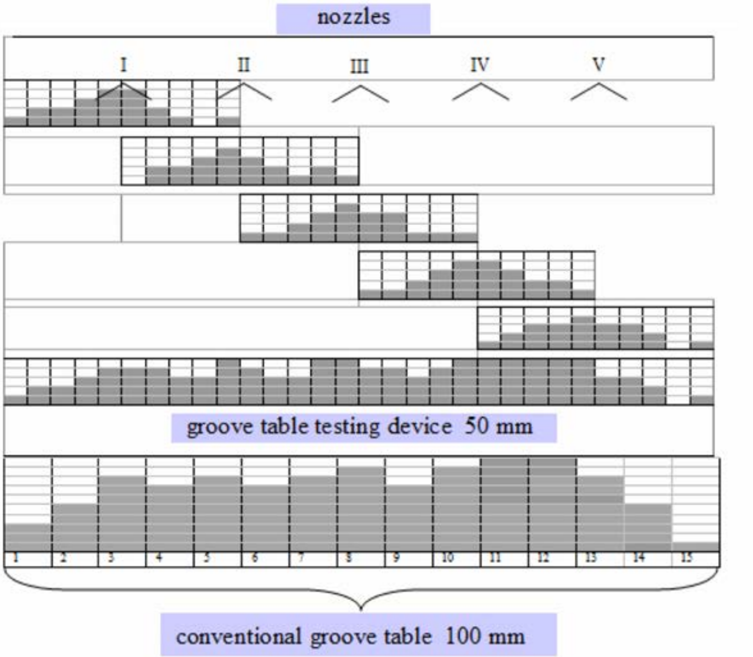

Fig. 4. Method of converting volumes of liquid table testing device (grooves 50 mm) for the table conventional patternator (grooves 100 mm)- virtual boom sprayer.Results of first tests and conclusion

The developed methods provide information on the individual parameters of spraying quality of each studied nozzle: flow rate, individual pattern (spraying angle, coefficient of asymmetry). Results of those studies are reliable and recorded in the electronic database, and then analyzed by means of a computer program. The converting studies results of transverse distribution under the boom (CV) for virtual spray boom and conventional patternator are inconclusive. Some conversion obtained results CV on virtual spray boom to the requirements of the conventional grooved table (100 mm) are presented in Tab. 3.

Tab. 3. Results of studied CV for some types of tested nozzles

A – CV virtual spray boom UP Lublin

B – CV conventional patternator CRA-W Gembloux

New nozzles **Nozzle type, spray at height 500 mm** **Pressure: 3 bars**				**Used nozzles** **Nozzle type, spray at height 500 mm** **Pressure: 3 bars**			
CV% - RS MM 110 04		CV% - HYPRO VP 110 03		CV% - Albuz ADI 110 04		CV% - TTD JET 110 04	
A	B	A	B	A	B	A	B
4,98	4,60	4,45	3.59	10,07	10,49	19,48	16,36
A-B = 0,38		A-B = 0,86		A-B = -0,42		A-B = 3,12	

The obtained results are not unequivocal for measured and simulated CV. More investigation are in realization.

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Test procedure for drift reducing equipment

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Summary

Drift is one of the main paths of plant protection products to non-target organisms. In Germany great efforts are made to reduce drift. Therefore sprayers are tested concerning their drift reducing ability in relation to the German basic drift values which have been determined on the basis of more than 180 drift trials with conventional sprayers. A classification system with classes of at least 50 %, 75 % and 90 % drift reduction has been introduced. Sprayers which meet the requirements of the German guideline are listed in the list of drift reducing sprayers. Nearly all of the sprayers are equipped with air injection nozzles to produce larger droplets. In orchards and hops further measures like shields on fan outlets, green detectors or tunnels are necessary to achieve the respective drift classes. Newer trials show that a drift reduction of 99 % in orchards is possible.

Introduction

Effects of plant protection products on non-target organisms are of great importance in the authorisation procedure. They are assessed on the basis of exposition data (GANZELMEIER, 2000). Drift is one of the main paths of plant protection products to non-target organisms. Therefore it is essential to improve sprayers so that drift can be reduced.
In field tests and wind tunnel tests the drift potential of sprayers and nozzles are measured. The results are compared with basic drift values which have been established in drift trial programs using conventional spray techniques (GANZELMEIER et al. 1995 and RAUTMANN et al. 2001).

Testing of Sprayers in Germany

In a voluntary test procedure manufactures have the opportunity to get the JKI-approval sticker. These sprayers or sprayer parts like nozzles are tested on a farm for at least one season and on JKI test stands. Manufacturers can apply for registration of their sprayer as a drift reducing sprayers if it has the JKI-approval sticker and if it has proven its drift reducing property. As a rule, an adequate amount of drift trials must be performed. The trials must be performed in accordance with guideline VII 2-1.1 „measuring direct drift when applying liquid plant protection products outdoors". Wind speed must be at least 2 m/s. The ground sediment must be measured in distances of 5 m, 10 m, 20 m, 30 m and 50 m.

Execution and assessment of trials

The assessment is made using one of the following alternative procedures.

1. Comparison with the basic drift values. At least 3 drift trials are to be performed with the equipment to be tested. For each distance, at least 30 measured values are necessary. From them the median values are to be calculated. From the median values of each distance a regression line in accordance with the method of minimal quadratic deviations is calculated. The classes of drift reduction are calculated from the median values, resulting from the tests done for the evaluation of the basic drift values.
2. Classification of the tested equipment is in the class which regression line is not exceeded within the total measured distance range by the regression line of the equipment to be examined.
3. Comparison with an already registered reference equipment. At least 3 drift trials are to be performed with the equipment to be tested as well as with the reference equipment. For each distance, at least 30 measured values are necessary in total per equipment. From the median values of each distance a regression line in accordance with the method of minimal quadratic deviations is calculated for the equipment to be tested as well as for the reference equipment.
4. Classification of the tested equipment is in the class in which the reference equipment is registered, if the regression line of the reference equipment is not exceeded within the total measured distance range by the regression line of the equipment to be examined.

5. If possible and asked for by the applicant for nozzles for field crops, through a comparison measurement with a reference nozzle. As a reference nozzle, a nozzle is to be taken which is already registered as a decisive part for the drift reduction of a field sprayer. The test is done in the wind tunnel in accordance with guideline VII 12.2.1 (currently in preparation). Classification is performed with the help of the «Drift-Potential-Index» (DIX) in the same class if the DIX is not higher than the DIX of the reference nozzle.

The plant protection equipment is registered in the list of loss reducing equipment if the examination has proved that the equipment possesses the drift reducing properties.

Drift reduction classes

According to the basic drift values there are different drift values for the drift reduction classes in various crops and growth stages (Tab. 1). For sprayers in other crops, those values are used that belong to the basic drift values used in the authorization procedure.

Tab. 1. Ground sediments in % of the application rate calculated on the basis of the median values

Dist.	Field crops			Fruit crops, early stages			Fruit crops, late stages			Grapes			Hops		
[m]															
	50%	75%	90%	50%	75%	90%	50%	75%	90%	50%	75%	90%	50%	75%	90%
1	0,48	0,24	0,10												
3				9,48	4,74	1,90	3,478	1,739	0,696	2,63	1,31	0,53	4,97	2,49	0,99
5	0,10	0,05	0,02	5,85	2,92	1,17	1,863	0,931	0,373	1,16	0,58	0,23	2,95	1,48	0,59
10	0,05	0,03	0,01	3,03	1,52	0,61	0,798	0,399	0,160	0,38	0,19	0,08	1,46	0,73	0,29
15	0,04	0,02	0,01	1,51	0,76	0,30	0,423	0,212	0,085	0,20	0,10	0,04	0,54	0,27	0,11
20	0,03	0,01	0,01	0,68	0,34	0,14	0,237	0,119	0,047	0,13	0,06	0,03	0,25	0,13	0,05
30	0,02	0,01	0,00	0,22	0,11	0,04	0,105	0,053	0,021	0,07	0,03	0,01	0,08	0,04	0,02
40	0,01	0,01	0,00	0,10	0,05	0,02	0,059	0,029	0,012	0,04	0,02	0,01	0,04	0,02	0,01
50	0,01	0,01	0,00	0,05	0,03	0,01	0,038	0,019	0,008	0,03	0,01	0,01	0,02	0,01	0,00

Listed sprayers

All classified sprayers are listed in the list of drift reducing equipment (Rautmann, 2001). There are more than 160 entries in this list. It includes field crop sprayers and air-assisted sprayers for orchards, hops and vineyards. Some sprayers for asparagus and red/blackcurrant are also listed. Application rules on pesticide labels refer to this list and prescribe buffer zones depending on the drift reduction class (Rautmann and Streloke, 2001).

Field crop sprayers can easily be equipped with air injection nozzles to reach the requirements for the drift reduction classes (Fig. 1). Dependent on the nozzle size and the spray pressure a drift reduction of 50 % up to 90 % is possible.

Sprayers with air-assistance achieve drift reductions of 50 % in crops with a minimum height of 30 cm and 75 % in crops with a minimum height of 50 cm.

Band sprayers, which are used for weed control in sugar beets or maize, are listed in the 90 % drift reduction class

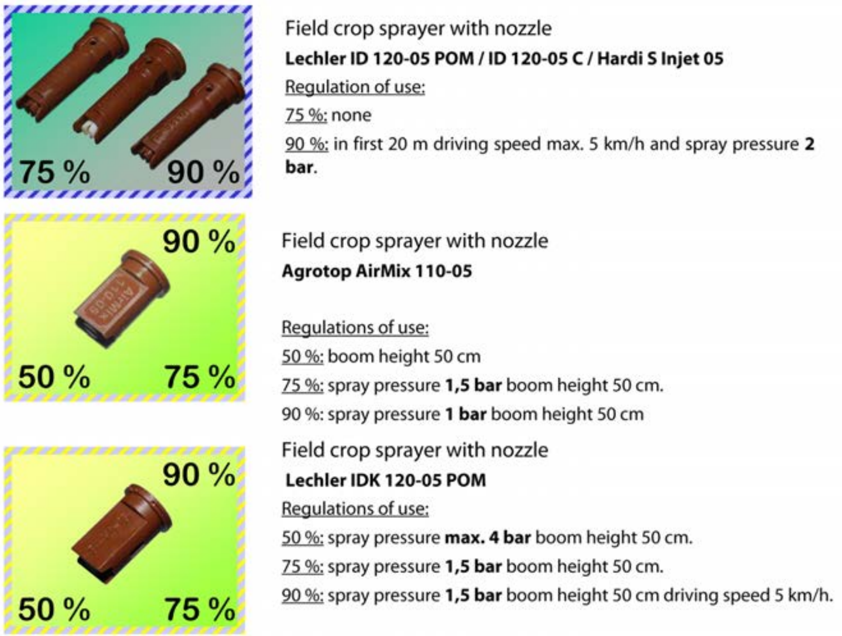

Fig. 1. Some examples of air injection nozzles for field crops.

In air blast sprayers for orchards, vineyards or hops air injection nozzles lead to drift reduction, too. However further steps are necessary to reach the mentioned drift reduction classes.

In orchards the air-assistance towards the field edge must be turned-off in the first five rows. This can be achieved with a cover shield on the fan outlet or a redirection metal sheet (Rautmann, 2001). The use of these sprayers does not result in added difficulties in comparison to standard sprayers. In contrary to tunnel sprayers there is no restriction fort the use on slopes.

Some sprayers are equipped with green detectors (Fig. 2). They will shut off the nozzles when no leaves are in sight. Even with hollow cone nozzles which produce fine droplets the drift reduction is at least 50 %.

Fig. 2. Orchard sprayers with green detectors.

Another possibility to reduce drift in orchards is to spray beneath a hail net. Depending on the nozzle types, drift reduction is at least 50 % sometimes 75 %.
When orchard sprayers with small axial fans (air flow reduced to 20 000m^3/h) and air injection nozzles are used, a drift reduction of 75 % has been found. Some sprayers with a cross-flow fan have been tested and could be classified in the 75 % and 90 % drift reduction class.
To reach adequate drift reduction in vineyards, it is necessary to spray the first two rows only inwards. But not all sprayers can be adapted to achieve a drift reduction of at least 50 %. If a sprayer of the 90 % drift reduction class is necessary, tunnel sprayers are used (Fig. 3).

Fig. 3. Two-row tunnel sprayer in a vineyard.

Drift reduction in hops is quite easy. Sprayers need a shield on one side of the fan outlet and air injection nozzles to spray the outermost part of the hop garden (Fig. 4). For the inner part of the hop garden the shield must be removed. This leads to a drift reduction of 90 %. Nearly all sprayers can be adapted in this way.

Fig. 4. Sprayer in hops with air injection nozzles and with shield on the fan outlet.

Conclusions

Drift reduction is a major task in sprayer testing and developments are going on.

In all major crops a significant drift reduction is possible often with simple means. The full list of drift reducing sprayers is available on the JKI website www.jki.bund.de. Manufacturers have realized, that drift reduction is an important point to preserve the environment but also an important argument in selling sprayers.

Further tests are necessary for sprayers for vineyards to find solutions for existing sprayers to improve the possibilities for drift reductions there.

Tests with a tunnel sprayer with air injection nozzles in orchard resulted in a drift reduction of 99 %. German authorities including JKI are now working on an extension of the list of drift reducing sprayers and on new regulations of use for pesticides considering this grade of reduction.

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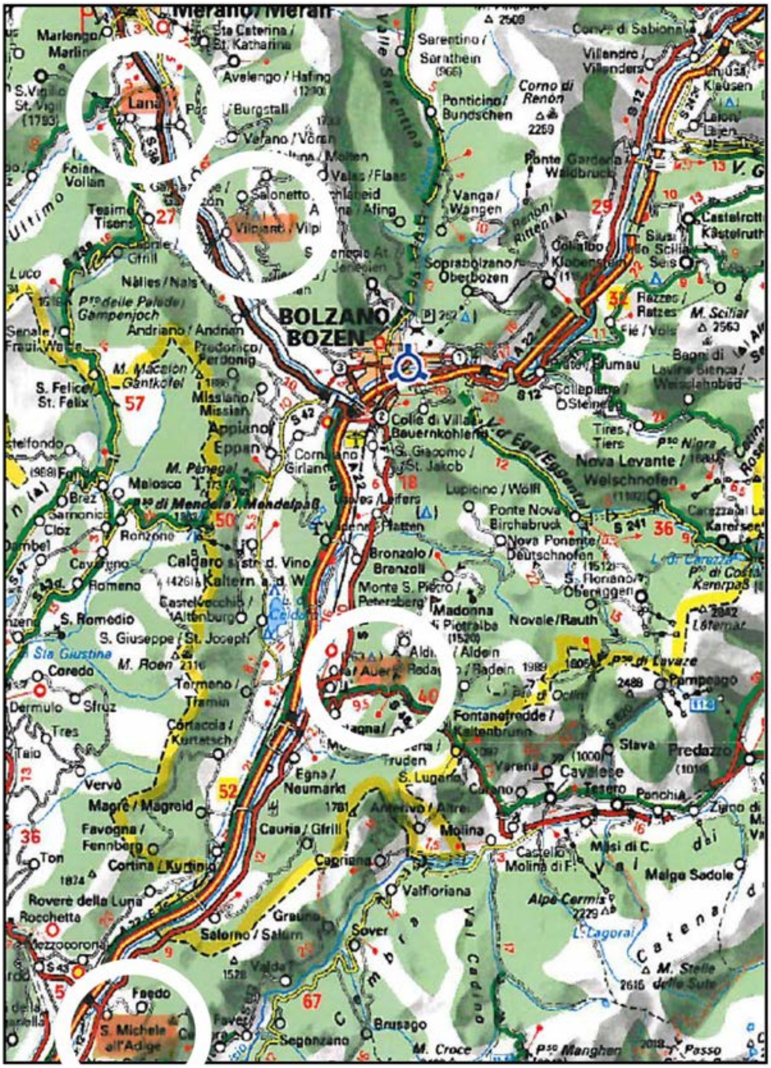
Excursion for visiting inspection centres

This excursion took place on the 28 March 2012. With this it should be achieved a better understanding for the work of inspection centres of the region of South Tyrol. Over that two research centres were visited regarding the investigations of air-assisted sprayers and knapsack sprayers.



Programme of the 28th March 2012
Lana

Fig. 1. Departure by bus from meeting point in front of the South Tyrolean Extension Service for Fruit- and Winegrowing.

Vilpian

Fig. 2 Visit of the sprayer manufacturer Lochmann. Visit of the sprayer calibration facility and air-flow test stand.

San Michele all'Adige

Fig. 3. Visit of the Research Centre Edmund Mach Foundation. Presentation of the results of the drift measurements in orchards and vineyards.

Auer/Pfatten

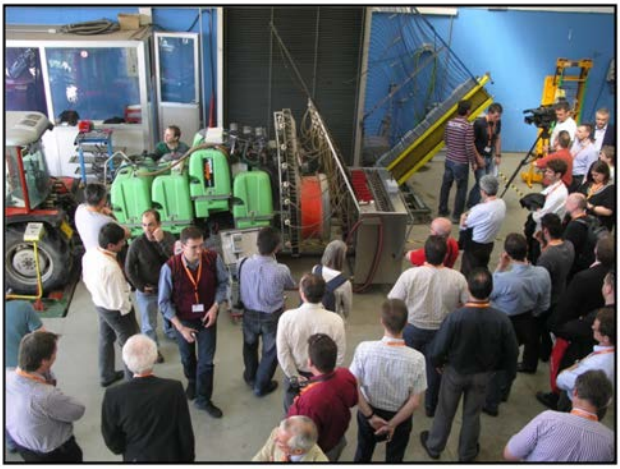


Fig. 4. Visit of the orchard- and vineyard-sprayer test facility. Demonstration of the inspection procedure and of spray drift reducing techniques.

Fig. 5. Visit of the Research Centre for Agriculture and Forestry Laimburg. Demonstration of spray drift reducing techniques in vineyards.

Fig. 6. Visit of the Research Centre for Agriculture and Forestry Laimburg. Presentation of trials on drift-reducing application techniques in apple orchards.

Laimburg/Stone Cellar

Fig. 7. Workshop dinner at the Stone Cellar of the Research Centre Laimburg

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Fourth European Workshop on Standardised Procedure for the Inspection of Sprayers in Europe – SPISE 4-

Die Richtlinie 2009/128/EC verpflichtet die Mitgliedstaaten bis spätestens 14. Dezember 2016 für Pflanzenschutzgeräte eine turnusmäßige technische Überprüfung einzuführen.
Die Mitgliedsstaaten sind für die praktische Umsetzung der europäischen Regelungen verantwortlich. Um die Details möglichst einheitlich festzulegen, ist ein umfangreicher Erfahrungsaustausch von großer Wichtigkeit. Die SPISE workshops bieten hierzu eine ideale Plattform. Vom 27. bis 29. März 2012 fand der vierte SPISE-Workshop in Lana (Italien) statt. Der Workshop wurde wieder organisiert von der SPISE Working Group (SWG), der Vertreter aus Belgien, Frankreich, Italien, Niederlande und Deutschland (Chairman: Dr.-Ing. H. Ganzelmeier) angehören. Die Teilnehmer kamen aus Prüfungs- oder Forschungsinstituten, Verwaltungen oder Firmen und brachten die nötige technische Expertise mit. Mit einer Beteiligung von ca. 100 Experten aus 29 Ländern ist dieser SPISE4-Workshop wiederum auf große Resonanz gestoßen.

Im vorliegenden Tagungsband sind alle Vorträge, Poster und weiteren Unterlagen des aktuellen Workshops zusammengestellt.

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The directive 2009/128/EC obliged the Member States to ensure that all pesticide application equipment in professional use shall be subject to inspections at regular intervals.
The Member States are responsible for the practical realization of the European regulations. To define the details as uniform as possible an extensive exchange of experience is essential. For this purpose the SPISE-workshops offer an excellent platform. From 27 to 29 March 2012 the fourth SPISE-Workshop took place at Lana (Italy). The Workshop was organised by the SPISE Working Group (SWG), to which representatives from Belgium, France, Italy, the Netherlands and Germany belong (Chairman: Dr.-Ing. H. Ganzelmeier). The participants came from inspection and research institutes, administration and private companies and brought with them the necessary technical expertise. The SPISE4-Workshop met with a very positive response, demonstrated by the 100 experts who took part from 29 European countries.

The present proceedings contain all presentations, posters and further documents of the latest workshop.

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