First European Workshop on Standardised Procedure for the Inspection of Sprayers in Europe -SPISE-
Braunschweig, Germany, April 27-29, 2004

Edited by

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Preface

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Plant protection is increasingly determined by sustainable management and consumers' expectations regarding the quality and reliability of our food. This plant protection is characterised amongst other things by high quality plant protection products, faultless and reliable plant protection equipment and experienced operators.

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

Regularly inspected sprayers are essential to guarantee:

- Sufficient control of the pest/disease with the minimum possible input of plant protection product
- Lower potential risk of environmental contamination by plant protection products
- Operator safety

The Member States are now concentrating increasingly on securing the faultless and reliable operation of their plant protection equipment by introducing a sprayer inspection.

A European standard which defines technical requirements for sprayer inspections was published at the beginning of 2003 and is to be used as a basis for the inspection of sprayers in the EU.

The aim of this three-day workshop was to familiarise the experts responsible in the Member States with this standard, to become acquainted with and exchange experience concerning existing inspections in the Member States and candidate countries and to establish an approach based on EN 13790, the aim of which is to create a sprayer inspection in Europe of consistent quality.

The conference was attended by experts who are responsible in their countries for establishing, organising, planning and carrying out voluntary or mandatory sprayer inspections as well as those responsible for the approval of inspection workshops and equipment.

It was therefore surprising that about 80 experts from 20 Member States and candidate countries took part in the SPISE workshop. The European Commission was also represented and presented its ideas on possible future European regulations for plant protection equipment.

The presentations were complemented by posters, an exhibition at the BBA of test facilities from European manufacturers/distributors and visits to officially approved inspection workshops which have been granted permission to carry out inspections in accordance with the BBA guidelines.

After the workshop, the presentations were made available to the participants in the form of Powerpoint-presentations. The long version of the presentations and the posters are published together with these workshop proceedings, which are distributed to all participants, and which can also be acquired by any other experts.

The participants welcomed this European initiative of the BBA and spoke for a continuation of such harmonisation work in the area of plant protection equipment inspections.

Braunschweig, April 2004

Heinz Ganzelmeier
Group portrait of the workshop participants
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Summary

The inspection of sprayers, which means the periodic inspection of sprayers in use, was the theme of the first European workshop, which took place at the Federal Biological Research Centre for Agriculture and Forestry (BBA) in Braunschweig from 27 to 29 April 2004. The basis for the workshop was the publication of a European standard at the beginning of last year, in which the technical requirements for the inspection of field crop sprayers and air-assisted sprayers for bush and tree crop was determined for the whole of Europe. This is seen as an important component in the harmonisation of sprayer inspections in Europe.

The aim of the workshop was to introduce this new standard to all the European Member States and candidate countries and to promote its implementation to create a reliable sprayer inspection of high technical quality. Since in addition to countries such as Belgium, Germany, the Netherlands and Poland – which introduced a compulsory inspection for sprayers several years ago – other Member States and candidate countries are discussing and preparing themselves for the introduction of sprayer inspections, the timing of the workshop was very fortunate. Eighty experts from 20 Member States and candidate countries came to Braunschweig.

The President of the BBA, Dr. Georg F. Backhaus, and the head of Plant Protection Department at the Ministry of Consumer Protection, Food and Agriculture (BMVEL), Dr. Petzold, opened the workshop and in doing so, emphasised the significance of this issue and this European initiative of the BBA. The Commission was also represented and presented its views with regard to possible ways of governing sprayers. The technical part of the workshop was introduced by two keynotes, presented by Mr. Liegeois on the subject of "Thematic strategy on the sustainable use of pesticides: an action plan to improve good plant protection practices throughout Europe" and Dr. Ganzelmeier on "European Standard EN 13790, the basis for sprayer inspections in Europe".

Mr. Liegeois emphasised in his presentation that the Commission has also included a number of measures for improving sprayer technology in the context of its environmental protection strategy. A first meeting of experts took place at the end of March 2004 in Brussels on aerial applications in the Member States. The SPISE workshop can be seen as the first European forum for exchanging experience and discussing measures for inspecting sprayers throughout Europe.

Dr. Ganzelmeier explained the first European standard EN 13790: work was started on this in the CEN/TC144 in 1997. It was published in the spring of 2003. First of all, this standard states, amongst other things, the following:

The three most important reasons for the inspection are

- the reduction of the risk to the environment through plant protection products,
- optimum plant protection using the least amount of plant protection product possible, and
- the safety of inspection personnel.

In order to make the use of plant protection products in European agricultural production safe, requirements and test methods for the inspection of sprayers already in use must be determined. This is a step further in the same direction following the standardisation of requirements for new sprayers relevant to environmental protection. Furthermore, it is stated that sprayers can be inspected on a voluntary basis, but also as an obligatory inspection. In both cases, detailed official or legal agreements are necessary on, for example, the implementation of inspections, the authorisation of places allowed to carry out inspections, the intervals between inspections, and so on. This European standard now determines requirements and methods for inspecting sprayers which are already in use. Through visual inspections, performance tests and by carrying out measurements, compliance with the specified requirements can be examined. A total of about 40 different requirements are stated which have to be tested during the inspection and recorded in the inspection report.

As already mentioned, this standard does not govern all aspects of the sprayer inspection. More extensive administrative regulations, technical prerequisites and a quality assurance system are needed. To be able to implement these associative measures in a binding form in all Member States and candidate countries when appropriate, further superordinate rules and regulations are necessary. This could be in the way of a
binding legal regulation in the EU or a voluntary commitment of the Member States and candidate countries (memorandum, network).

The present situation regarding sprayer inspections in the Member States and candidate countries is marked at present by great differences between the Member States and candidate countries. It shows that at present, sprayer inspections are obligatory by law only in Germany, Belgium, the Netherlands and Poland. Several countries intend to introduce an obligatory inspection in the next few years. In several Member States or candidate countries, a voluntary sprayer inspection either exists or is in the process of being established. In many cases, the inspection is organised and implemented in a different manner, depending on the particular region.

The sprayer inspection is seen by the participants as a major contribution to high quality environmental and operator protection as well as food safety. Most Member States and candidate countries are involved in the introduction of a sprayer inspection (pilot project, voluntary inspection or obligatory inspection). Particularly interesting was that the European Commission does not see the need for further technical requirements for sprayers already in use and for new sprayers which go beyond EN 13790 and EN 12761. Representatives from the Member States and candidate countries propose a sprayers inspection which is uniform throughout the EU and endorse the implementation of EN 13790 by the Member States and candidate countries. It was also evident that in the Member States, the organisation, responsibility (private, state-approved) and consequences of the inspection (if requirements are not fulfilled) are governed in very different ways. The Member States and candidate countries use different test benches for measuring the vertical distribution of air-assisted sprayers. Often, the inspection facilities do not fulfil requirements in accordance with EN 13790. The Member States and candidate countries therefore see the need for further administrative and technical agreements which go beyond EN 13790, in the following areas:

- commitment to a voluntary / obligatory inspection,
- organisation / competencies,
- test procedure for both new and used sprayers,
- approved inspection workshops,
- definition of "minor defects",
- consequences if requirements are not met,
- guidelines for introducing sprayer inspections.

The exchange of information between Member States and candidate countries is also seen as very important and should therefore be developed further. The quality of the inspection is determined mainly by the inspection workshop, the authorised inspection personnel and the monitoring system for approved workshops. Only a few Member States have introduced a quality management system (e.g. accreditation in accordance with EN 45004). The Member States countries therefore see an urgent need for regulating (exchange of information) quality management, training inspection personnel and testing the inspection facilities.

At present, several individual regulations exist in the different countries, which allow mutual acceptance on a bilateral level (e.g. D / NL, B / NL). An important prerequisite for the mutual acceptance of sprayer inspections is that EN 13790 is implemented throughout the whole of the EU. A sprayer inspection for the whole of the EU should therefore only be introduced on the basis of EN 13790.

Furthermore, representatives from the Member States and candidate countries endorse the implementation of a "European Steering Committee" to support the harmonisation of the sprayer inspection and to safeguard conditions of competition. Action is seen as necessary in the following areas:

- agreeing on the various regulations in the Member States and candidate countries,
- guarantee a reliable and precise sprayers inspection,
- regular monitoring on inspection workshops regarding their way of working,
improving operator knowledge, and

convincing users of the benefits and the need for sprayer inspections.

In addition, the compilation of guidelines / instructions on the mutual acceptance of inspections between Member States and candidate countries is encouraged.

Finally, the main conclusions of the SPISE-Workshop are emphasised in a joint resolution:

The participants

• welcome the fact that the Member States and candidate countries are considering introducing sprayers inspections,

• would welcome the fact that Member States and candidate countries would continue their work on harmonisation and mutual acceptance,

• support the idea of a working group (B, NL, I, F, D) for preparing further steps for harmonisation in agreement with the EU-Commission and a second SPISE workshop.

The presentations were complemented by posters, an exhibition of test facilities from European manufacturers/distributors in and around the testing hall of the Division for Application Techniques, and an excursion to approved inspection workshops.

Acknowledgement

Special thanks to Mrs. Buerig for support in translation of the workshop documents.
Welcoming address

BACKHAUS, G.F.
President of the Federal Biological Research Centre for Agriculture and Forestry (BBA), Messeweg 11/12,
D-38104 Braunschweig, Germany

Dear Mr. Liegeois,
dear Dr. Petzold,
dear Ladies and Gentlemen,

I cordially welcome you in our Federal Biological Research Centre for Agriculture and Forestry here at
our campus in Braunschweig. I am very pleased that you followed the invitation to participate in SPISE -
the first workshop for the inspection of sprayers in Europe. I wish to express my special gratitude to the
organisers of this important meeting and also to those organisations which support this meeting, in
particular our Federal Ministry for Consumer Protection, Food and Agriculture, the European
Commission, the German Phytomedical Society and – last not least – the German Engineering
Federation, Agricultural Technology.

It is about time, indeed, to come together within an European framework in order to exchange
information about the type, manner and extend of current equipment inspections and the manifold
national regulations and to discuss all these information with special reference to the future needs for
uniform European actions and regulations of high quality as well as the need for harmonisation means.

The Federal Biological Research Centre is one of the organisations in Europe with a long scientific and
administrative tradition, history and experience in the field of phytomedicine and plant protection - as
well as, of course - of application technologies for plant protection products of all kinds. I would like to
give you a short overview about our organisation and its activities.

The Federal Biological Research Centre for Agriculture and Forestry is an independent higher federal
authority and research institution. It is subordinate to the Federal Ministry of Consumer Protection, Food
and Agriculture.

The BBA was founded and established in Berlin more than 100 years ago. The BBA’s research in the
large field of phytomedicine contributes to sustainable maintenance of the cultivated landscape and
people’s quality of living.

Nowadays the BBA is established in Braunschweig and in Berlin and has institutes in five additional
locations: Kleinmachnow, Bernkastel-Kues, Darmstadt, Dossenheim and Münster.

The BBA has about 500 permanent staff members, including 120 scientists. In addition, there is a
varying number of non-permanent positions financed by external sources. The BBA’s budget for 2003
amounted to about 40 million Euro.

The BBA consists of one department, 13 institutes, the division for application techniques and a number
of central services.

The BBA’s tasks are laid down in the German Crop Protection Act, and the Gene Technology Act. In the
framework of the authorisation of plant protection products the BBA evaluates their efficacy,
phytotoxicity, resistance management and actual benefit. Its statement has to be obtained for product
authorisation. The BBA furthermore tests plant protection equipment and keeps an official list of tested
plant protection machinery. It develops methods to test crop plant varieties for their potential resistance
towards diseases and helps in the general testing of plant varieties. The BBA is also involved in the
procedure for the approval of release and marketing of genetically modified plants. Another important
field of work consists in regulatory activities regarding plant inspection and plant quarantine within the
European Union.

The BBA’s administrative tasks are tightly woven with research activities, which gives its decisions a
solid basis of up-to-date scientific and technological understanding.
In the framework of the political foci and the research plan which is set out by the Federal Ministry of Consumer Protection, Food and Agriculture, the BBA’s research work is aimed at developing methods and techniques to protect plants and plant products, and to avert any dangers which might arise from plant protection measures to the health of man, animal and the natural balance.

The basis for any plant protection is diagnosing the causes of damage to plants. BBA scientists look into the functions of pest and plant disease organisms and diagnose plant diseases. They are working on biochemical, molecular-biological and serological methods suited to detect important pests and diseases. The BBA develops methods and strategies for integrated plant protection.

BBA scientists study the effects and fate of plant protection products in cultivated landscape and work on methods of post-registration monitoring of plant protection products. In the context of releasing genetically modified organisms, the BBA does comprehensive research on biological and ecological safety. With its research the BBA contributes to safeguarding a manifold cultural landscape and biological diversity.

Last not least, a bit more specified, the main duties of our Application Technique Division:

According to the German Plant Protection Act, a manufacturer or distributor who places new plant protection equipment on the market has to declare that this equipment meets legal requirements. The Application Technique Division of the BBA examines this declaration and the documentation submitted together with it. The equipment may be tested and is then registered in an official list of plant protection equipment and published in the Federal Gazette. Only such registered equipment may be sold. Manufacturers may also have their equipment tested at the facilities of the Division of Application Techniques on a voluntary basis. The Plant Protection Act also regulates the examination of used equipment.

The Application Techniques Division updates regulations and guidelines for equipment testing and brings them in line with state of the art technology. It is involved in the development of European and international standards for plant protection equipment with regard to environmental protection and carries out research to this end.

The Division of Application Techniques of the BBA is equipped with a modern testing hall, with offices and laboratories, an air-conditioned wind channel and test benches to test oscillation, cross distribution and fans.

Ladies and Gentlemen,

I learned that you will also make excursions to another kind of technology that is dominant in the region of Braunschweig, as you will visit the VW factory in Wolfsburg, which is only about 30 km away from here. And indeed the region of Braunschweig is extremely science- and technology oriented, as there is not only a large technical university with round about 30,000 students; here you also find 7 large governmental research organisations that work in the fields of biotechnology, aeronautic and space research, physical technology, agriculture and material science. I am sure, Dr. Ganzelmeier will give you a detailed overview of all these activities.

I wish you every success for your consultations and scientific discussions and I really regret that I will not be able to spend more time with you, as other duties are waiting for me. I also wish you very fruitful and interesting personal contacts and discussions and a close insight into our region.

Thank you for your attention.

G.F. Backhaus
Welcoming address

PETZOLD, R.
Ministry of Consumer Protection, Food and Agriculture, Rochusstraße 1, D- 53123 Bonn, Germany

President Dr. Backhaus,
Ladies and Gentlemen,
on behalf of the Ministry of Consumer Protection, Food and Agriculture which supervises the Federal Biological Research Centre it’s a pleasure for me to bring the best regards to this important workshop. I am especially pleased about the high number of participants, showing the interest of our neighbour countries, including the accession countries or, in a few days, the new members of the European Union.

Ladies and Gentlemen,

let me give you a short outline of the political line we have taken in Germany as far as plant protection equipment is concerned. Plant protection equipment is one part of the iron triangle as we call it in Germany. This iron triangle contains three important elements. Firstly, the well trained farmer, secondly, sound chemical and non-chemical means aimed two-fold to do a good job and to protect the operator, the consumer and the environment sufficiently at the same time, and last not least the equipment to spray such chemical means, the plant protection products.

Nearly twenty years ago we recognised in Germany at federal level that non mandatory checks of plant protection equipment fail. Only up to 40 % of the existing sprayers were checked regularly. Therefore an improvement was required. Primarily by enforcing an Act and - specified by regulation - a provision was introduced in Germany, saying that new types of plant protection equipment have to meet specific requirements. Declarations to this end have to be submitted to the BBA by the company wanting to market such equipment. Secondly equipment which is in use has to be checked against these requirements. So mandatory checks have been introduced since then. We started 1993 with field sprayers, because the necessary knowledge for sound checks was already available, and two years ago we amended the Regulation and therefore fruit, vegetable, wine or hop growers have to subject their plant protection equipment to regularly checks.

In contrast to the well developed provisions for plant protection products at EU-level such harmonised provisions do not exist for plant protection equipment. Of course, there is a Directive for machinery including sprayers aimed to safeguard operators but this Directive does not deal with spraying quality or possible negative impacts for human health or the environment through dysfunctions, incorrect distribution of the plant protection product and so on.

For this reason we have appreciated very much the establishment of EN 13790 and the announcement of the European Commission within the thematic strategy for a sustainable use of pesticides, to step in and to improve this area by harmonisation.

In the meantime the conditions at least at the scientific level for the marketing of plant protection equipment in a common market should be developed further.

If a common understanding of the necessary requirements and about the suitable inspections can be reached at EU-level we will have made a very important step. I hope this workshop will contribute to this aim at least as a first step. A follow up should also be given some thought.

I wish you successful talks, fruitful discussions and that you keep the SPISE 2004 in Brunswick in good memory.

Thank you very much for your attention.

R. Petzold
Introduction to the workshop

GANZELMEIER, H.
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The starting point for this workshop is the fact that the European standard EN 13790, 'Inspection of Sprayers in Use', with parts 1 and 2, was published at the beginning of 2003. We experts in the Member States (MS) and candidate countries (CC) then asked ourselves how we should handle the standard and what we should do as a follow-up to what had already been achieved. The CEN members are obliged in accordance with CEN regulations to give the European standard EN 13790 the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2003; conflicting national standards are to be withdrawn at the latest by November 2003. Urgent action must therefore be taken.

My first talks with colleagues on the subject of creating a European platform to advise on continuing the process were very positive. This made me begin with concrete plans for this workshop.

The reason we are setting the workshop now in spring is due to the fact that

- plant protection inspections take place at exactly this time and are thus a current topic for us all,

and

- plant protection inspections can be experienced live in spring, a special aspect of our Workshop.

In preparing and organising the programme we, and by we I mean my colleagues on the scientific committee, as well as my colleagues from the Application Techniques Division, were led by the following considerations. I would like to illustrate these by the next figure, fig. 1. The present situation in the Member States and candidate countries is characterised by great differences.

This will become clear in the talks and posters on Session 1 (S1). The resulting disadvantages do not have to be explained in detail. The fact that this situation calls for changes was recognised by CEN members back in 1997. On the 17th of July of the same year, work on a European standard was included in the CEN/TC 144 programme of work. Following around 6 years' work, European standard EN 13790 was published in the spring of last year (2003).

As is generally known, and also stated in the preface to the standard, it does not cover all aspects, but only the technical requirements for the plant protection equipment to be inspected and the testing facilities used.
Figure 1: Present situation (S1) and need for regulation (S2, S3, S4) for a „standardized procedure for inspection of sprayers in Europe“, coming to an equivalent inspection with mutual recognition (S5)

All Member States and candidate countries who have had previous experience with the plant protection equipment inspections know that further

- administrative regulations (S2)
- technical prerequisites (S3) and a
- quality management system (S4)

are needed to be able to assure reliable plant protection equipment inspections of constant high quality in the Member States.

In addition to EN 13790, these aspects should be treated within the framework of our workshop. In order to implement this in a binding manner in all Member States and candidate countries, a superordinate body of controlling/supervising is needed.

In my opinion, this can be a

- legal regulation from the EU or MS or a
- voluntary undertaking of the MS and CC, like a Common Memorandum of forward looking MS or an European Network for inspection of sprayers in Europe.

Mr. Liegeois will, I am sure, be able to tell us more about this.

In my opinion, plant protection equipment inspections of constant high quality can only be achieved by a combination of measures.

This will result in (S5)

- inspections being accepted throughout the Member States and candidate countries,
- multiple inspections becoming unnecessary in the future.

What expectations have you brought with you, and what results can be achieved?

Each of us will have his own ideas and expectations, but I would still like to mention a few myself, fig. 2.
Subjects of the Spise-Workshop

- Get to know of MS/CC experts dealing with inspection of sprayers
- Familiarize the MS/CC with the action plan of the COM
- Familiarize the MS/CC with the European Norm EN 13790
- Exchange of results and experience of the current situation in MS/CC and their comparison with EN 13790 (S1)
- Think about further official/legal specifications in order to make sure inspections run reliable and smoothly
  - Administrative regulations required for establishing an inspection (S2)
  - Technical prerequisites for conducting inspections (S3)
  - Quality management for inspections (S4)
- The following subjects have to be discussed:
  - How to deal with minor defects?
  - How to deal with inspection stickers?
- Definition of action plan to establish the EN 13790 and to realize inspections of equal quality throughout MS/CC for mutual recognition
- Resolution about continuing the harmonization of inspection sprayers in Europe

Figure 2: Subjects of the Spise-Workshop

You can find additional documents for the workshop course in the book of abstracts.

I hope that now you feel very convenient, the programme meets your approval and I wish our workshop a good course.
Keynotes

Thematic strategy on the sustainable use of pesticides: an action plan to improve good plant protection practices throughout Europe

LIEGEOS, E.
European Commission, DG Environment, Unit Biotechnology and Pesticides, Rue de la Loi, 200, B-Brussels, Belgium

Summary

The sixth environment action plan approved in July 2002 did propose to develop beside the current regulatory framework (authorisation directive and monitoring directive) a new holistic approach to fill existing gaps by tackling in particular the use phase.

A communication was therefore published by the Commission in July 2002 in order to launch consultations of stakeholders and European institutions. The consultation resulted in numerous contributions which in overall supported the objectives and first thoughts of the Commission. One of the potential measures to be included in the forthcoming thematic strategy will concern the spraying equipment. The Commission intends to at least recommend the establishment of technical check of spraying equipment in use on the one hand and certification of new equipment on the other hand.

A study has been circulated to assess the (positive and negative) impacts of such potential measures for manufacturers, authorities, equipment owners, their health and the environment. The first results of this study will be presented and will likely justify the final proposal adopted by the Commission, based on the overall balance between efficiency and costs.

1. Introduction

Sustainable use of pesticides is not a new concept. It was already addressed in earlier action programmes. Moreover several studies were initiated by Member States, and national action programmes were put in place. Among the most important initiatives the main ones were:

- studies for the development and evaluation of future strategies for plant protection products, which were guided by a Steering Committee established by the Commission and the Dutch authorities,
- the 5th environment action programme as revised in 1998,
- the Cardiff process for 'environmental integration and sustainable development in the common agricultural policy'.

Finally, with the adoption of the 6EAP, the Council and the Parliament called for the elaboration of this thematic strategy on the sustainable use of pesticides and determined the goalposts and objectives of such a new tool.

2. Thematic strategies, new horizontal tools

In its Communication ‘Towards a Thematic Strategy on the Sustainable Use of Pesticides’ of July 2002, the Commission launched the broad consultation of all stakeholders and institutions. The Communication noted the shortcomings of the current situation with regard to plant protection products and proposed tracks and possible measures to inverse negative trends by addressing the use stage more specifically. Other thematic strategies will be developed in the same time and some are particularly relevant to tackle complementary aspects of the safe use and surveys of the impacts of plant protection products, like the strategies for soil protection, for the marine environment, the environment and health strategy.

3. Objectives of the thematic strategy

According to the 6EAP, the main objective of the thematic strategy is to reduce the impacts of pesticides on human health and the environment and more generally to achieve a more sustainable use of pesticides
as well as a significant overall reduction in risks, but also a reduction of the use of pesticides consistent with the necessary crop protection.

In particular, the objectives of the thematic strategy, as defined in the 6EAP, are the following:

1. to minimise the hazards and risks to health and environment from the use of pesticides.
2. to improve controls on the use and distribution of pesticides.
3. to reduce the levels of harmful active substances, in particular by replacing the most dangerous by safer (including non-chemical) alternatives.
4. to encourage the use of low-input or pesticide-free crop farming.
5. to establish a transparent system for reporting and monitoring progress including the development of appropriate indicators.

4. Results of the broad consultation on the Commission communication

The consultation organised by the Commission and based on indications and possible measures presented in the communication, encompassed the Council, the European Economic and Social Committee, the European Parliament and the general public. More than 150 contributions from diverse stakeholders were received (via the Internet and via a stakeholders’ conference in November 2002). Several representatives from candidate countries were actively participating to the stakeholders’ conference.

Opinions submitted are available at the following addresses:

- For the stakeholders http://www.europa.eu.int/comm/environment/ppps/home.htm
- For the Council (Council Environment, 9 December 2002) at: http://register.consilium.eu.int/isoregister/frames/intromnfsEN.htm
- For the European Economic and Social Committee, the EESC (NAT session, 23 January 2003 - Rapporteur Staffan Nilsson) at: http://www.esc.eu.int/scripts/avis.asp?type=en

The objectives and many of the possible measures, as outlined in chapter VI of the communication, were broadly supported by the consulted stakeholders and institutions.

In the following the main results from the consultation will be presented.

5. The scope of the thematic strategy

Despite the call addressed to the Commission (in particular by the Parliament) to also include biocides, the Commission will focus its first actions on plant protection products (used to protect plants and plant products against harmful organisms), for the reasons outlined in the Communication (legal references set up in the 6EAP, state of play with the biocides directive). However, uses outside the agricultural sector will also be taken into consideration. In other words, biocides are in a first instance not addressed by the thematic strategy.

5.1 Measures discussed in the communication and reactions from the stakeholders

DG environment is currently in the process of preparing the most adequate proposals regarding these measures. Different scenarios and flexible content could be envisaged for each measure. They could range from a highly prescriptive, legislative approach at Community level to a de-centralised (subsidiarity) approach leaving full flexibility to Member States. This project will be based on the results of the extensive consultation with key stakeholders including EU Member ad candidate states as well as industry, environmental, farming and consumer organisations. An extensive impact assessment, meaning study or estimate of impacts on economic, social and environmental aspects will be conducted for each
new proposal. Here again the participation of the authorities and the concerned stakeholders will be determining. The participants to this conference were therefore strongly solicited by the author to participate in the data collection effort currently in progress.

The extended impact assessment is aimed at

- identifying material, information and economic flows
- identifying the cause/effect relations
- identifying the relevant stakeholders
- developing several policy options
- assessing the socio-economical, environmental and health impacts (negative and positive) expected from several policy options and from that establish a ranking of the most eco-efficient option for a given measure.

6. The format of the strategy

The 6th environment action programme does not define the legal form of the thematic strategy. The Commission therefore has full flexibility to choose the most appropriate form. In the communication, the Commission considers that in implementing the strategy, the Community and the Member States could use many different instruments: legally binding measures, (economic) incentives, research or voluntary measures. Combination of all types of instruments is also possible. Many measures could most effectively be integrated in already existing or currently developing related policy areas.

From the consultation, one observed that, if the Council calls for coherence with the revision of directive 91/414/EEC while taking into account the principle of subsidiarity, the EESC considers that this strategy should operate as an umbrella framework and include existing legislation, probably also proposing new legislation.

The EP favours a more centralised approach, stresses the need for urgent and mandatory complementary action in addition to directive 91/414/EEC and calls on the Commission to develop binding and effective measures. The EP urges the Commission to co-ordinate the internal work on drawing up the proposals for a thematic strategy and an amended Directive 91/414/EEC.

6.1 National action plans

The Commission considers the establishment of national action plans to be the central piece of the thematic strategy because they will offer the necessary flexibility for Member States while ensuring overall coherence. For this aspect again, the consultation reveals a clear opposition between the Council asking for maximum subsidiarity for Member States and the Parliament calling for mandatory (combined with voluntary) measures established on a Community basis. The Council would like to see the Commission’s role limited to providing only guidance for certain key measures. The Parliament asks for binding and effective goals and timetables to be established for each Member State via national reduction plans that will cover the following aspects:

- assessment of existing situation at Member State level
- awareness raising campaigns
- designation of vulnerable zones
- monitoring in environmental media
- regular progress reports by Member States on the implementation of reduction programmes
- crop protection licenses, drift reduction measures, disease prevention measures, use and approval of spraying equipment.
6.2 Improved systems for the collection of information on distribution and use and enhanced compliance/monitoring schemes including annual reporting

In the Communication, the Commission proposed relevant mandatory requirements within two years of the adoption of the thematic strategy for the reinforcement of ongoing work on the collection of data concerning use (quantities of PPPs applied per crop, product, area, time of application…).

6.3 Training of users, standards for spraying equipment and collection of containers and obsolete pesticides

The Commission has been broadly encouraged by the consulted institutions and by all stakeholders to develop requirements regarding the training of professional users and the improvement of the awareness of non-professional users; the establishment of quality standards and the associated suitable control system of spraying equipment (based on the current harmonisation work of CEN) because they are considered potentially as important source of diffuse pollution (exceeded doses applied); the collection of empty containers and obsolete pesticides at farm level, because they are considered as potentially important source of point pollution.

The initiative of this SPISE workshop is particularly welcome as one of the major pillar of the future Thematic Strategy would be to improve the quality of the sprayers, either by implementing inspection of sprayers in use according to the European standard EN 13790, or either by certifying sprayers before their placing on the market then according to the standards EN 907 and EN 12761. Whether both measures will become compulsory or voluntary is not yet decided, nor is the way to organise the control and certification infrastructure (public or private).

7. Other potential measures to be developed

Other potential measures, which, albeit considered being part of the thematic strategy and addressing its general objectives, could probably best be implemented in other already existing legislation. This is namely the case for measures targeting:

- The enhanced protection of the aquatic environment which is clearly addressed by the water framework directive and its daughter directives (like the groundwater directive, which will be revised soon).
- A better monitoring or more epidemiological surveys regarding the exposure of the consumers and the environment from the use of plant protection products: the Commission is actually considering that the annual residue monitoring programmes for instance could be extended (more intense or better orientated sampling programme). This could be tackled via the existing (or the newly proposed) residue legislation. Other tracks will be studied later when the objectives and content of the Strategy on Environment and Health will be defined.
- An overall reduction of the levels of harmful active substances, in particular by replacing the most dangerous by safer (including non-chemical) alternatives. This is the famous concept of comparative assessment. Generally supported as a principle by all stakeholders and institutions consulted, there were only very few comments on practical implementation.
- Comparative assessment: The Commission is reflecting on a new proposal in the framework of the modification of directive 91/414/EEC to insert this comparative assessment concept. This could be done in an equivalent manner as already included in the existing article 10(5) of the directive 98/8/EC on the placing on the market of biocides. The Commission will try to apply the substitution principle extensively where relevant, where practically feasible and economically viable. It will consider a priori all products, various stages of the authorisation process (Community or national level, decisions taken by the authorities or by farmers). It has to take duly account of resistance management and of the results of the current review process under Directive 91/414/EEC for old active ingredients. A priori this could not exclude any potential alternatives (organic, biological/microbials, GMOs).
- The harmonisation of VAT via an amendment of the relevant regulation, as it was generally supported by the consulted institutions as an important tool avoiding illegal import from Member States applying a smaller VAT rate.
8. Conclusions

The thematic strategy on the sustainable use of pesticides will represent with the revision of the directive 91/414/EEC and the new regulation on the establishment of maximum residue limits the third main cornerstones of the future regulatory framework for the plant protection products. This will be situated between the two up and down stream levels of the PPP life-cycle.

The Commission has to develop a broad range of instruments and tools to achieve the objectives of reducing risks for the consumer, user and the environment. Amongst them, the inspection of the spraying machines according to the harmonised EU standard EN 13790 will represent a major piece of the whole thematic strategy, together with product comparison (comparative assessment) and training of the users. From now on the preparation of the competent authorities should start in order to be ready to implement this challenging measure. However, every new measures proposed by the Commission will be first extensively assessed for its potential impacts. This is the task of the next coming months. More details could be communicated during the conference and discussed with the key stakeholders present. The proposal for the thematic strategy will come after these extensive impact assessments, as announced in the course of 2004.

Acknowledgements: Special thanks to Mrs. Jacqueline Voituron for support in preparing the conference participation and presentation.
European standard EN 13790 - the basis for sprayer inspections in Europe

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Summary

EN 13790 continues to be characterised by the fact that

- it brings together in one standard the different procedures, findings and technical requirements which have existed in the Member States up to now,
- it is established on the basis of test methods and requirements which have proved reliable in the Member States in the past,
- it achieves a high technical level whilst not consuming unnecessary time or money,
- the Member States are obliged to apply this standard and to withdraw respective national standards,
- it represents a basis for the harmonisation of sprayer inspections and the future mutual acceptance of inspections between the Member States,
- it determines technical requirements but does not anticipate regulatory decisions made by the Member States and the EU.

1. Introduction

Already when choosing the title for my talk, I draw a conclusion which is far-reaching, but which cannot seriously be put into question by anybody. Then for what other reason have we developed this standard than to achieve high-quality uniform sprayer inspections in Europe? It was not always easy in the many meetings we had to bring together the varying experiences and ideas of the countries/colleagues concerned. In the end, the interests in a common European standard predominated over individual interests. I would now like to introduce the EN 13790 to you; unfortunately, to be able to do this, great many technical details must be included. This is also necessary when a subject as complicated as the inspection of plant protection equipment is to be regulated and implemented clearly, exactly and in a transparent manner.

2. Foreword, introduction and scope of the standard EN 13790

At the beginning of the standard, the following aspects are mentioned:

During recent years, several countries have developed systems for inspection of sprayers in use. Developments in this direction have been stimulated by public concern about risks, and the aim of reducing the use of crop protection products.

However, there are three main arguments for the inspection:

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

This European Standard consists of the following parts, under the general title agricultural machinery sprayers - Inspection of sprayers in use:

- Part 1: Field crop sprayers.
- Part 2: Air-assisted sprayers for bush and tree crops.
This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2003, and conflicting national standards shall be withdrawn at the latest by November 2003.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom. The following Candidate Countries are already a member of CEN since 01 January 2004: Estonia, Lithuania, Latvia, Poland, Slovenia, Cyprus.

In order to use crop protection products in agricultural production in Europe safely, it is necessary to define the requirements and test methods for sprayers in use. This is a relevant step after having standardized the requirements for new equipment, in respect of safety hazards (see EN 907) and potential risks of environmental contamination (see EN 12761 Parts 1 to 3). The inspection of sprayers in use can be done on a voluntary or mandatory basis. In both cases further official or legal specifications are necessary, e.g. on the execution management of the inspection, which organisations are authorised to carry out the inspection, time intervals between inspections etc...

As the specifications of this European Standard are based on EN 907 and EN 12761, it may be the case that sprayers in use which were produced before EN 907 and EN 12761 came into force do not fulfil all the specifications given in this European Standard. Standardising the requirements and methods for inspection of sprayers in use, takes into consideration not only the original performance of the spraying equipment, but also its use, care and maintenance. This is the logical link between new equipment of good quality and well educated and concerned users.

This European Standard specifies the requirements and methods of their verification for the inspection of sprayers in use. It relates mainly to the condition of the sprayer in respect of safety hazards for the test operator, the potential risk of environmental contamination and opportunities to achieve good application.

The compliance with the requirements defined in the following clauses shall be checked by inspection, function tests and measurements.

3. Requirements

Now I would like to carry on with the explanations of the technical requirements. These requirements must be fulfilled by the sprayers to be inspected.

Altogether around 40 different requirements for field sprayers as well as for air assisted sprayers are mentioned which have to be tested and the results of which have to be recorded.

I want to introduce only a choice of the most interesting points. The numbering of the features mentioned in the following corresponds to the EN 13790.
4.1.1
The power take-off (PTO) drive shaft guard and the guard of the power input connection (PIC) shall be fitted and in good condition:

The protective devices and any moving or rotating power transmission parts shall not be affected in their function.

Method of verification: inspection and function test.

4.2.1
The pump capacity shall be suited to the needs of the equipment.

a) The pump capacity shall be at least 90% of its original nominal flow, given by the manufacturer of the sprayer.

Method of verification: measurement according to 5.2.1.a).
4.2.1
b) the pump shall have sufficient flow rate capacity in order to be able to spray at maximum working pressure as recommended by the sprayer or the nozzle manufacturer during test with the largest nozzles mounted on the boom while maintaining a visible agitation as specified in 4.3.

Method of verification: measurement according to 5.2.1.b).

4.2.2
There shall be no visible pulsations caused by the pump.

Method of verification: inspection and function test.
4.4.2
There shall be a strainer in good condition in the filling hole.
Method of verification: inspection.

4.4.5
There shall be a clearly readable liquid level indicator on the tank which is visible from the driver's position and from where the tank is filled.
Method of verification: inspection.
4.5.1
All devices for measuring, switching on and off and adjusting pressure and/or flowrate shall work reliably and there shall be no leakages.

Method of verification: inspection and function test.

4.5.2
The controls necessary for spraying shall be mounted in such a way that they can be easily reached and operated during the application and information provided for example on displays that can be read respectively. Switching off and on of all nozzles shall be possible simultaneously.

Method of verification: inspection.
4.5.3 / 4.5.4
The scale of the pressure gauge shall be clearly readable and suitable for the working pressure range used.
Method of verification: inspection.

4.5.5
For analogue pressure gauges the minimum diameter of the pressure gauge cases shall be 63 mm.
Method of verification: measurement.
4.5.6
The accuracy of the pressure gauge shall be ± 0.2 bar for working pressures between 1 bar (included) and 2 bar: ± 10 % for working pressures > 2 bar.
Method of verification: according to 5.2.3.

4.6.1
There shall be no leakages from pipes or hoses when tested up to the maximum obtainable pressure for the system.
Method of verification: inspection and function test.
4.8.1
The boom shall be stable in all directions, i.e. not loose in any joints and not be bent. The right and the left parts of the boom shall be of the same length.

Method of verification: inspection.

4.8.2
When provided, the automatic resetting of booms shall operate if fitted with the device, to move backwards and forwards, in case of contact with obstacles.

Method of verification: inspection and function test.
4.8.4
The nozzle spacing and their orientation shall be uniform along the boom, except for special equipment such as border spraying. By design, it shall not be possible to modify unintentionally the position of the nozzles in working conditions, for example by folding/unfolding the boom.

Method of verification: inspection and measurement.

4.8.5
When measured stationary on a level surface, the distance between the lower edges of the nozzles and the surface shall not vary more than 10 cm or 1% of the half working width.

Method of verification: inspection and measurement.
4.8.8
It shall be possible to switch on and off individual boom sections.

**Method of verification:** inspection and function test.

4.9.1
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. Other components (nozzle filters, anti drip devices) shall be equivalent all along the boom.

**Method of verification:** inspection.
4.9.2
After being switched off, the nozzles shall not drip. 5 s after the spray jet has collapsed there shall be no dripping.
Method of verification: inspection.

4.10
For the transverse distribution, the requirements and test methods of 4.10.1 or 4.10.2 shall apply.
NOTE 1: If nozzles are used on a boom to form a uniform spray, 4.10.1 or 4.10.2 applies; in other cases, 4.10.2 applies.
NOTE 2: A compared evaluation of the two methods given in 4.10.1 and 4.10.2 will be carried out during the revision of this standard to check whether preference may be given to one of these methods.
4.10.1
a) The transverse distribution, within the total overlapped range, shall be uniform. The transverse distribution is evaluated on the basis of the coefficient of variation which shall not exceed 10%.
b) the amount of liquid collected by each patternator groove within the overlapped range shall not deviate more than ± 20% of the total mean value.

Method of verification: measurement according to 5.2.4.

4.10.2.1
The deviation of the flow rate of each nozzle of the same type shall not exceed ± 10% of the nominal flow rate indicated by the manufacturer.

Method of verification: measurement according to 5.2.5.
4.10.2.2
The pressure drop between the measuring point for pressure on the sprayer and the end of each boom section width shall not exceed 10 % of the pressure shown on the pressure gauge.

Method of verification: measurement according to 5.2.6.

5.1
Before the inspection takes place, the sprayer shall be carefully cleaned. Certain attention shall be paid to rinsing and internal cleaning of the sprayer including filters and filters inserts, and external cleaning of those parts of the sprayer that are most exposed to the crop protection product when spraying. Visible and other known faults should preferably be remedied before the inspection. A preparatory "rough inspection" should be done at the site of the ordinary inspection, in order to avoid wasting time making measurements on sprayers with very obvious serious faults. The owner/operator of the sprayer should preferably be present at the inspection.
5.2 Test facilities and methods.
5.2.1 Pump capacity measurement.
5.2.2 Verification of the sprayers pressure gauges.
5.2.3 Flow meters for controlling the volume/hectare rate.
5.2.4 Measurement of the uniformity of the transverse volume.
5.2.5 Measurement of the flow rate.
5.2.6 Measurement of pressure drop.
5.2.7 Measurement of pressure variation when the sections are closed.
5.2.8 Other test facilities.

An example of a test report is given in annex B.

<table>
<thead>
<tr>
<th>Test station</th>
<th>Test Report</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>for the inspection of field crop sprayers</td>
</tr>
<tr>
<td></td>
<td>according to EN 13790 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Owner's identity:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer ……..</td>
</tr>
<tr>
<td>Type ……………………………………………………………………………………..</td>
</tr>
<tr>
<td>Serial No ……………</td>
</tr>
<tr>
<td>Year of construction ………………………………………………………………..</td>
</tr>
<tr>
<td>Mounted ☐</td>
</tr>
<tr>
<td>Owned by ☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Remarks:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Result of the inspection</th>
<th>Signature ……………………………………………………………………………………..</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ too distant</td>
<td>☐ too close</td>
</tr>
</tbody>
</table>
continued from example of test report

<table>
<thead>
<tr>
<th>Subject</th>
<th>Description</th>
<th>Requirement</th>
<th>Defect</th>
<th>General remarks on the state of the sprayer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Drive transmission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Agitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Spray liquid</td>
<td>Volume</td>
<td></td>
<td>Leakage</td>
<td></td>
</tr>
<tr>
<td>5. Measuring system, control and regulating elements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Filter and</td>
<td></td>
<td></td>
<td>Leakage</td>
<td></td>
</tr>
<tr>
<td>filters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Fitting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Spray boom</td>
<td>Working with</td>
<td></td>
<td>Stability/straightness</td>
<td></td>
</tr>
<tr>
<td>9. Nozzles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Dry or</td>
<td>Actual Cv...</td>
<td></td>
<td>Coefficient of variation (±10 %)</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. A test report shall be given to the user directly following the inspection at the inspection site. This report shall mention any malfunctions of the sprayer and inform the user of the repairs required to be made to his equipment. The test report shall also include the results of the measurements.

8. (proposal)
The inspection service fills the sticker in with address...and sticks it on the sprayer after the inspection has shown that the sprayer functions without fault. The sticker may also handed out if the sprayer has minor defects which the owner undertakes to remove immediately.
4.9.1
All devices for adjusting pressure shall maintain a constant working pressure with a tolerance of ± 10 % at constant rotational speed and reach the same working pressure after the equipment has been switched off and on again.

Method of verification: inspection and function test.
4.9.2
The output of each nozzle with the same marking shall not deviate more than $\leq 15\%$ from the nominal output or $10\%$ from the mean output of all nozzles within the same identification.
For symmetrical spraying, the difference between the left and right hand sides mean output shall be a maximum of $\leq 10\%$.

Method of verification: measurement according to 5.2.4.

4.9.3
The pressure difference at each section inlet shall be a maximum of $\leq 15\%$.

Method of verification: measurement according to 5.2.4.
4.9.4
NOTE: In order to provide the owner/operator with further information in addition to 4.9.1 to 4.9.3, the spray distribution may be measured by using a vertical patternator test bench according to 4.10.1 of EN 13790-1:2003.

4. Further Comments

For evaluating the cross-distribution of field crop sprayers, two test-methods are allowed:

The cross-distribution measuring using a groove patternator (4.10.1) and the single nozzle flow rate measuring (4.10.2) are recognised. This compromise should be clarified during the next revision of this standard whether preference may be given to one of these methods.

References

Session 1 - Actual inspections in the Member States and their comparison with EN 13790

Inspection of sprayers in Italy with special regard to the Piemonte region

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Summary

Actually the service to have sprayers inspected is only available in 9 of the 20 Italian regions: Piemonte, Lombardia, Veneto, Trentino Alto Adige, Emilia Romagna, Toscana, Marche, Molise and Lazio. In additional seven regions the inspections are conducted just at experimental or demonstrating level. Nevertheless, in the regions where the inspection service is put into practice, it is carried through with different criteria.

In the Piemonte region, the inspection of sprayers in use is mandatory for the about 15000 farms that adhere to the regional Rural Plan of Development (PSR 2000-2006) that is in accordance with the European Regulation EC 1257/99. Twenty authorised inspection centres are now active in the whole region, involving about 80 technicians, trained with specific courses held at the University of Turin. In the period 2001-2003 about 3100 sprayers were inspected in Piemonte.

1. Introduction

The inspection and the calibration of sprayers in use, as well as the certification of the performances and safety requirements of new sprayers, are fundamental in order to achieve good quality pesticide application, making it possible to mitigate the environmental risks related to this practice, to prevent operator contamination and to improve the quality of agricultural products.

In Italy there is still no national law concerning the inspection and adjustment of sprayers in use; just in some Italian regions directives issued by the local administrations on this subject are actually in force. In most cases the inspection is only mandatory for the sprayers of the farms that take part in the plans of rural development based on regulation EC 1257/99 (Balsari and Vieri, 1996). The lack of national coordination on this sector makes it therefore difficult to monitor inspection activities in the country. In order to collect information about the number of sprayers inspected per year in each region and to verify the test methodology and the equipment adopted, a questionnaire prepared by DEIAFA – University of Turin has been submitted to all regional administrations and to the test stations involved in sprayer inspections all around Italy.

2. The inspection of sprayers in Italy

First inspections of sprayers in Italy were carried out in 1980 in the Bolzano province by the first official test station for checking air-assisted sprayers. Until the second half of the nineties very few other test stations were activated; only between 1996 and 1999, thanks to the definition of an interregional directive (Misura 4 Piano Interregionale Agricoltura e Qualità), some regions promoted the sprayer inspection service. At first it was only at demonstration and experimental level, then inspections became mandatory for a certain part of the machines. The test methodology recommended by the Misura 4 directive basically referred to the EN 13790, table 1. According to an estimation, until 2003 less than 4% of the about 550000 sprayers in use in Italy were inspected.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Misura 4 (Italy)</th>
<th>EN 13790</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump: capacity</td>
<td>no indications</td>
<td>pump capacity shall be at least 90% of the nominal capacity indicated by the manufacturer</td>
</tr>
<tr>
<td>Pump: flow rate</td>
<td>optional - verify the flow rate</td>
<td>the flow rate shall be sufficient to allow the liquid pulverisation at the maximum pressure indicated by the manufacturer</td>
</tr>
<tr>
<td>Pump: pulsations</td>
<td>no indications</td>
<td>There shall be no visible pulsations caused by the pump</td>
</tr>
<tr>
<td>Pump: leakages</td>
<td>There shall be no leakages (e.g. dripping) from the pump.</td>
<td>There shall be no leakages (e.g. dripping) from the pump.</td>
</tr>
<tr>
<td>Pressure safety valve</td>
<td>When there is a pressure safety valve on the pressure side of the pump, this valve shall work reliably.</td>
<td>When there is a pressure safety valve on the pressure side of the pump, this valve shall work reliably.</td>
</tr>
<tr>
<td>Agitation system</td>
<td>optional - A clearly visible recirculation shall be achieved when spraying at the nominal p.t.o speed, with the tank filled to the half of its nominal capacity.</td>
<td>A clearly visible recirculation shall be achieved when spraying at the nominal p.t.o speed, with the tank filled to the half of its nominal capacity.</td>
</tr>
<tr>
<td>Main tank: leakages</td>
<td>optional - verify that the cover is sealed to the filling hole.</td>
<td>There shall be no leakages from the tank or from the filling hole when the cover is closed.</td>
</tr>
<tr>
<td>Main tank: filter</td>
<td>There shall be a strainer in good condition in the filling hole.</td>
<td>There shall be a strainer in good condition in the filling hole.</td>
</tr>
<tr>
<td>Tank contents indicator</td>
<td>optional - There shall be a clearly readable liquid level indicator on the tank which is visible from the driver's position and from where the tank is filled.</td>
<td>There shall be a clearly readable liquid level indicator on the tank which is visible from the driver's position and from where the tank is filled.</td>
</tr>
<tr>
<td>Maximum discrepancies between vertical distances along the boom (only for boom sprayers)</td>
<td>100 mm per m of boom</td>
<td>When measured stationary on a level surface, the distance between the lower edges of the nozzles and the surface shall not vary more than 10 cm or 1% of the half working width.</td>
</tr>
<tr>
<td>Filtering system</td>
<td>There shall be at least one filter on the pressure side of the pump and in case of positive displacement pumps also one filter on the suction side.</td>
<td>There shall be at least one filter on the pressure side of the pump and in case of positive displacement pumps also one filter on the suction side.</td>
</tr>
<tr>
<td>Pressure gauge: position</td>
<td>It shall be readable from the driver seat.</td>
<td>It shall be readable from the driver seat.</td>
</tr>
<tr>
<td>Pressure gauge: scale</td>
<td>Boom sprayers: the scale shall be marked at least every 1 bar up to the boom working pressure. Air assisted sprayers: the scale shall be marked at least every 2 bar up to 20 bar.</td>
<td>The scale of the pressure gauge shall be clearly readable and suitable for the working pressure range used.</td>
</tr>
<tr>
<td>Pressure gauge: diameter</td>
<td>min 63 mm</td>
<td>min 63 mm</td>
</tr>
<tr>
<td>Pressure gauge: accuracy</td>
<td>max 5% discrepancy with respect to the sampled value.</td>
<td>The accuracy of the pressure gauge shall be ± 0,2 bar for working pressures between 1 bar (included) and 2 bar (included). From a pressure of 2 bar, the pressure gauge shall measure with an accuracy of ± 10% of the real value.</td>
</tr>
<tr>
<td>Antidrip devices</td>
<td>After being switched off, the nozzles shall not drip. 10 s after the spray jet has collapsed there shall be no dripping.</td>
<td>After being switched off, the nozzles shall not drip. 5 s after the spray jet has collapsed there shall be no dripping.</td>
</tr>
<tr>
<td>Boom sprayers: Evenness of nozzle flow rates.</td>
<td>The deviation of the flow rate of each nozzle of the same type shall not exceed ± 10% of the average flow rate measured on the boom nozzles.</td>
<td>The deviation of the flow rate of each nozzle of the same type shall not exceed ± 10% of the nominal flow rate indicated by the manufacturer.</td>
</tr>
<tr>
<td>Air-assisted sprayers: Evenness of nozzle flow rates</td>
<td>The difference between the left and right hand sides mean output shall be a maximum of 5%.</td>
<td>The output of each nozzle with the same marking shall not deviate more than 15% from the nominal output or 10% from the mean output of all nozzles within the same identification. For symmetrical spraying, the difference between the left and right hand sides mean output shall be a maximum of 10%.</td>
</tr>
<tr>
<td>Hoses and pipes</td>
<td>There shall be no leakages from pipes or hoses when tested up to the maximum obtainable pressure for the system. Hoses in working positions shall not be suspended in the range of the spray.</td>
<td>There shall be no leakages from pipes or hoses when tested up to the maximum obtainable pressure for the system. Hoses in working positions shall not be suspended in the range of the spray.</td>
</tr>
<tr>
<td>Pressure regulator</td>
<td>When measured at the inlet of the boom sections, the pressure shall not vary more than 10%, when the sections are closed one by one.</td>
<td>When measured at the inlet of the boom sections, the pressure shall not vary more than 10%, when the sections are closed one by one.</td>
</tr>
<tr>
<td>Boom sprayers: spray transverse distribution diagram</td>
<td>visual evaluation</td>
<td>The transverse distribution, within the total overlapped range, shall be uniform. The transverse distribution is evaluated on the basis of the coefficient of variation which shall not exceed 10% and the amount of liquid collected by each patterner groove within the overlapped range shall not deviate more than ± 20% of the total mean value.</td>
</tr>
<tr>
<td>Air-assisted sprayers: spray vertical distribution diagram</td>
<td>visual evaluation</td>
<td>optional</td>
</tr>
</tbody>
</table>
According to the survey carried out by DEIAFA, actually 120 recognised test stations are active in 16 of the 20 Italian regions, fig. 2. In detail, in 8 regions (Piemonte, Lombardia, Veneto, Emilia Romagna, Toscana, Marche, Molise and Lazio) and in the provinces of Trento and Bolzano (Trentino Alto Adige) the sprayers inspection is mandatory. In 7 regions (Friuli, Abruzzo, Puglia, Sicilia, Campania, Basilicata and Calabria) the inspection is still voluntary or at demonstration level. In the remaining 4 regions there is no inspection service available.

In the Toscana region the inspection of field crop sprayers is now mandatory for all farmers, while in the other regions it is mandatory just for those farms that receive the subsidies according to Regulation CE 1257/99. In Emilia Romagna, for instance, the sprayer inspection service refers to the farms which mark their products with the QC (Quality Controlled) label and those involved in the regional technical assistance plan (Regional Law LR 28/98).

In summary, sprayer inspections are actually mandatory for about 40% of the Italian farms, corresponding to 51% of the nationally usable agricultural lands. Generally, sprayers have to be inspected every 5 years and new sprayers certified by ENAMA (National Board for Agricultural Mechanisation) are dispensed for the first 5 years of use.

Inspections are generally conducted in private test stations (authorised workshops, agricultural cooperatives, agrarian consortiums, etc.). In 63 % of cases tests are carried out by personnel from private
companies (farmers associations, workshops) while in the other cases, especially where the inspection service is at experimental level and voluntary, verifications are carried out by technicians from Public Boards supported by personnel from the Universities, table 2. The technicians are generally trained in specific courses taking 20-80 hours, fig. 3. The sprayer inspection is generally performed by two technicians in collaboration with the farmer.

**Table 2**: Authorised sprayer inspectors in the different Italian regions.

<table>
<thead>
<tr>
<th>Region</th>
<th>Authorised Inspectors</th>
<th>Number of technicians per inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piemonte</td>
<td>technicians from farmers’ associations, private companies for technical assistance</td>
<td>2</td>
</tr>
<tr>
<td>Lombardia</td>
<td>technicians from farmers’ associations, private workshops, provincial public services</td>
<td>2÷3</td>
</tr>
<tr>
<td>Veneto</td>
<td>technicians from farmers’ associations, private workshops</td>
<td>2</td>
</tr>
<tr>
<td>Toscana</td>
<td>private workshops</td>
<td>2</td>
</tr>
<tr>
<td>Emilia Romagna</td>
<td>private workshops</td>
<td>2</td>
</tr>
<tr>
<td>Molise</td>
<td>regional agency of plant protection (COREDIMO)</td>
<td>2</td>
</tr>
<tr>
<td>Lazio</td>
<td>technicians from farmers’ associations</td>
<td>2</td>
</tr>
<tr>
<td>Abruzzo</td>
<td>regional agency for agricultural development (ARSSA)</td>
<td>2</td>
</tr>
<tr>
<td>Puglia</td>
<td>regional consortium for plant protection</td>
<td>2</td>
</tr>
<tr>
<td>Friuli Venezia Giulia</td>
<td>private workshops, regional agency for agricultural development (ERSA)</td>
<td>2</td>
</tr>
<tr>
<td>Marche</td>
<td>private workshops</td>
<td>2</td>
</tr>
<tr>
<td>Basilicata</td>
<td>regional agency for development and innovation in agriculture (ALSIA)</td>
<td>2</td>
</tr>
<tr>
<td>Calabria</td>
<td>regional agency for agricultural development (ARSSA)</td>
<td>3</td>
</tr>
<tr>
<td>Sicilia</td>
<td>regional administration</td>
<td>3</td>
</tr>
<tr>
<td>Province of Trento</td>
<td>private workshops</td>
<td>2</td>
</tr>
<tr>
<td>Province of Bolzano</td>
<td>private workshops, public assistance board for fruit and viticulture</td>
<td>5</td>
</tr>
</tbody>
</table>

The 124 test stations active in Italy actually operate with 186 test benches (on average 1.5 test bench per station): 96 (52 %) are used for the inspection of air-assisted sprayers for arboreal crops and 90 (48 %) to evaluate boom sprayers, fig. 3.
Different models of vertical test benches are employed in these test stations. The more spread types are fitted with square trays (Mibo-DEIAFA), with inclined trays (Tanesini), with vertical lamellae (Extel) and with horizontal lamellae (Pessl). Some assembled equipment meeting the criteria required by the test protocols are also in use. Moreover, in some areas (i.e. in Puglia, where vines are often trained according to the Tendone system), special test benches modelled according to the specific shape and size of the canopies are employed.

The time needed for the inspection of one sprayer varies (from 60 to 150 minutes, 110 minutes on average) according to the features of the machine (boom or air-assisted sprayer, number of nozzles) and to the level of sprayer maintenance performed by the user, fig. 4.

Nevertheless, just 35% of the inspection time is spent for the sprayer adjustment (40 min on average), but at 25% of the test stations the calibration procedures are carried out in not more than 15 minutes, Fig. 5.

In almost all regions where the inspection is mandatory, the costs for the service is paid by the farmer (eventually as a reduction of the subsidy in the ambit of the CE 1257/99 regulation). On the other hand,
where the inspection service is still voluntary, the costs are paid by regional administrations. In details, the maximum cost allowed by the regions for one single sprayer inspection ranges from 65 Euro (Abruzzo) to 206 Euro (Lombardia).

In the last three years about 17000 sprayers were inspected in Italy. The number of machines controlled per region in the period 2001-2003 ranged from 60 (Molise) to 6100 (Emilia Romagna). The number of sprayers checked in the regions where the inspection is mandatory in the same period, 2001-2003, ranged from 120 to 6100, fig. 6.

![Figure 6: Average number of sprayer inspections per test station carried out in the period 2001-2003.](image)

3. The sprayer inspection in the Piemonte region

In Piemonte (North West Italy), at the beginning of the nineties, the regional public administration started some experimental activities within the Project of Integrated Crop Pest Management.

In 1996 a specific experimental project was approved by the region Piemonte and was carried on since 1999 with the collaboration of DEIAFA - University of Turin. This project was extremely useful for pointing out the importance of the procedures of the functional inspections, for instructing technical operators, and for establishing a regional model to standardise the calibration procedures and for the creation of centres on the territory certified to apply the calibration procedures. One of the results of the project was the realisation of a software to store all information on each sprayer tested and the issuing of certificates.

In 2000 the region Piemonte started the Project for the Development of Rural Areas (PSR), that took into account the CE 1257/99 regulation. In this project the functional inspection of sprayers became mandatory for all farms (about 15000) involved in the project and for the ones that receive EU subsidies for low environmental impact agriculture which required improvement of the regional network for functional inspections. The region Piemonte issued also instructions for the authorisation of centres, for them to legally carry through functional inspections and calibrations, and approved the methodology for carrying out inspections, fig. 7.

Since 2001, 20 centres have obtained the authorisation to carry through functional inspections and calibration of boom sprayers and air-assisted sprayers in Piemonte. In the meantime, with the collaboration of DEIAFA, the region Piemonte has organised several courses to train technical operators. After having passed a theoretical and practical exam, currently about 130 technicians have obtained the qualification for the calibration of boom sprayers, air-assisted sprayers or both. For them the region Piemonte also organises updating courses and draws up didactic manuals.
The models of sprayers on the market officially certified by ENAMA (National Board for Agricultural Mechanisation) are dispensed from the inspection during their initial 5 years of use.

Problems of a topographic nature (farms located far away from inhabited centres and/or from the workshops), typical of the Piemonte area, prevent inspections to be carried out at mechanical workshops with fixed equipment which are spread all over the territory. When designing the equipment for functional inspections it was necessary to take into account the need to minimise dimensions, weights and also costs. Hence, the DEIAFA, in collaboration with the company MIBO, designed equipment that is easily transported by car and can be handled by just two persons and which makes functional inspections of air-assisted sprayers directly on the farm or at farm products collection centres possible.

Functioning of the main sprayer components is checked partially according to the guidelines stated by the EN 13790 standard. The main differences concern the assessment of the vertical spray pattern of air-assisted sprayers (limit: index of symmetry < 10), the verification of the forward speed of all types of sprayers, and the parameter used for the calculation of the effective volume application rate.

The diagnostic inspection can be interrupted each time a parameter is encountered that does not fall within the acceptable limits. In this case, the technician writes down recommendations (i.e. change of manometer, revision of the pressure regulator, etc.) on a specific sheet and leaves a copy with the farmer who, after having fixed up the sprayer, makes an appointment for another inspection.

![Figure 7: Organisation chart of the inspection in Piemonte.](image)

All data collected by technicians on the forms during inspection activities are processed by computer using a dedicated software –by the regional Administration and DEIAFA – that, if the check values are complete and within the limits, results in printing the final test report for the farmer. This report also contains some indications about sprayer adjustment (i.e., operating pressure, forward speed, volume application rate). A label stating the test year and a sequential identification number is then issued and has to be fixed on the sprayer, in accordance with the test protocol requirements, fig. 8.

With respect to EN 13790, the test protocol actually adopted in Piemonte differs in regard to the assessment of the vertical spray pattern of the air-assisted sprayers (limit: index of symmetry < 10), regarding the verification of the forward speed, and the parameter used for calculating the effective volume application rate.

During their first three years (2001-2003) the inspection service in Piemonte controlled 3093 sprayers (769 boom sprayers and 2324 air-assisted sprayers). 84 technicians worked in the territory and the average number of machines inspected per technician amounts to 37.
4. Conclusions

The actual percentage of sprayers inspected in Italy amounts to just about 4% of the machines in use, a very low value if compared with other European countries. Registered most frequent inadequacies of inspected sprayers concern the pressure gauge (often featured by an inadequate scale and/or a scale which was not precise enough), the lack of a readable and functioning tank content indicator and the lack of antidrip devices.

A national co-ordination of the inspection of sprayers in Italy would be necessary in order to promote an inspection service distributed all over the country and based on common rules. This would require the organisation of new test stations and appropriate training of the technicians authorised to carry through controls.

References

Obligatory inspection of sprayers in Poland - organisation and first experiences

HOLOWNICKI, R.; DORUCHOWSKI, G.; GODYN, A.; SWIECHOWSKI, W.
Research Institute of Pomology and Floriculture, Spraying Technique Education Center,
Pomologiczna 18, PL-96-100, Skierniewice, Poland

Summary

Inspection of sprayers has been obligatory in Poland since 1999 for all tractor mounted, trailed and self propelled sprayers, used both in fruit growing and field crops. The inspection was enacted in 1995 by the Plant Protection Act followed by the directive of the Ministry of Agriculture in which the rules, organisation and procedure of the inspection was described. The principles of the inspection are very similar to those in the EN 13790 standards. However, the requirements are less restrictive and some items are verified by visual evaluation or functional test instead of measurements of technical parameters. The national system of inspection of sprayers in use is organised and supervised by the Plant Health and Seed Inspection Service. The system includes 321 officially approved commercial testing units. The testing units are usually run by the dealers of agricultural machines, distributors of agrochemicals as well as agricultural high schools and extension services. The personnel of inspection units have to attend a 5 day training course in one of six centres of education in plant protection technique. It is followed by the governmental examination. The training course includes 15 hours of lectures and 20 hours of practical training on inspection, calibration and modernisation of sprayers. In Poland 32.76 % of 302 000 sprayers have been inspected so far. The cost of inspection is partly covered by the governmental subvention in order to attract farmers operating on small and low income farms.

1. Introduction

Poland is a medium-sized country in Europe with a relatively large area of agricultural land of poor soil quality. Therefore the agricultural land with the worst soil quality lies fallow to be used for forestation. The use of active ingredients contained in plant protection products (PPP) amounts to only 0.6 kg/ha. It prevents the country from the severe problem of environmental pollution caused by pesticides. During monitoring of agricultural products by the Plant Health and Seed Inspection Service no excess of the standard limits of PPP residues have been found. Cases of accidental pollution of the soil and surface water were not considered. It can be expected that in future the use of PPP in Poland will increase significantly in order to improve the quality and competitiveness of our agricultural production in the EU. However, the increased use of PPP can be hazardous for the environment.

Around 302 000 field crop sprayers are in use. The typical field crop sprayer is equipped with a 300 l tank and a 10-12 m spray boom. Many sprayers are self-made by the farmers and they require some modernisation. In the last 2-3 years the best selling sprayers were equipped with 1000-2000 l tanks and 15 -18 m booms.

In Poland 28000 air-assisted orchard sprayers are used. The typical orchard sprayer is a trailed machine equipped with an axial fan and a 1000 l tank. Only very few of them are mounted sprayers. The best developed sector of Polish agriculture is horticulture. The use of PPP is much higher in this sector and therefore a lot of attention has to be paid in order to prevent the environment from being polluted by pesticides.

In recent years the quality and the technical level of sprayers produced in Poland increased significantly. This was possible because of an easy access to the best components from abroad. The leading European manufactures of sprayers are also present on our market. They share less than 10% of the market. The prices of these machines are 50-80% higher than for Polish ones and therefore they are purchased only by most demanding customers.
2. Mandatory inspection of sprayers

2.1 Objectives and advantages of inspection

Efficient plant protection requires improving operator safety, decreasing the use of chemicals and reducing their environmental impact. These objectives are being realised in Poland by the obligatory:

- keeping record of the spray applications,
- training for the operators,
- inspection of sprayers “in use”.

The above mentioned regulations are the main components of a safer food production chain. They guarantee identification of traceability and finally improve the consumer’s confidence in agricultural products. Improved design and reliability of the sprayers are most fundamental for decreasing the risk of environmental contamination by pesticides while maintaining their biological effect. The clear and educative method of inspection was proposed in order to improve knowledge of the farmers. Low costs and little effort should motivate farmers to have their sprayers tested. During the inspection the farmers obtain objective information on the technical state of their sprayers and advice on calibration and proper spray application in the field.

2.2 Organisation

Mandatory inspection of sprayers was laid down in 1995 in the Plant Protection Act. They should have started in 1999. A four year period for preparing the rules and the principles of the inspection was proposed. Inspection includes tractor driven and self-propelled sprayers. Knapsack sprayers, equipment for recreation areas and spraying installations for greenhouses are not included. The basic principles which describe the technical requirements of the sprayers as well as the necessary diagnostic equipment were proposed by the Minister of Agriculture. The first cycle of inspection should have been finished by the end of 2001.

The national system of testing sprayers in use is organised and supervised by the Plant Health and Seed Inspection Service. It includes 321 officially approved commercial testing units, table 1. The testing units were usually established by the dealers of agricultural machines, distributors of agrochemicals and agriculture high schools and extension service centres. The personnel of test station has to pass the official examination after a five day training course in one of six Spraying Technique Education Centers distributed in Poland. The training course includes 15 hours of lectures and 20 hours of practical training on testing, calibration and modernising sprayers. By the end of 2003 the Centers trained 1322 inspectors from testing units and officers from regional Plant Health and Seed Inspection Services, table 1.

Table 1: The number of testing units, inspected sprayers and trained personnel in the years 2000-2003

<table>
<thead>
<tr>
<th>Year</th>
<th>Testing units</th>
<th>Sprayers</th>
<th>Trained personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>153</td>
<td>8 968</td>
<td>860</td>
</tr>
<tr>
<td>2001</td>
<td>100</td>
<td>19 200</td>
<td>284</td>
</tr>
<tr>
<td>2002</td>
<td>56</td>
<td>33 553</td>
<td>96</td>
</tr>
<tr>
<td>2003</td>
<td>12</td>
<td>37 141</td>
<td>82</td>
</tr>
<tr>
<td>Total</td>
<td>321</td>
<td>98 862</td>
<td>1322</td>
</tr>
</tbody>
</table>

For economical reasons and because of a relatively high number of small and old sprayers used on low income farms some governmental subventions are granted to the growers to cover part of inspection costs. The subvention is not higher than 50 % of the total costs for inspection and depends on the type and size of sprayer. Each farmer can also apply for financial support from the National Environmental Fond. It may be used to cover up to 50% of the costs for modernising the vital components influencing the final spraying result (spray boom, nozzles, nozzle holders with anti-drip valves, pump, agitation).

The Polish system of sprayer testing has two specific attributes which are not typical for mandatory inspection. The first is the obligatory inspection of new sprayers. Though the inspection was meant to be for sprayers “in use”, the farmers want to buy machines which are officially approved and are not subject
to inspection in their initial 2-3 years. They want to be sure that a new sprayer has been manufactured properly according to the standards. The second attribute is the fact that the testing units carry out minor sprayer repairs during inspection (exchange of used nozzles, manometers, etc). Both attributes were introduced in Poland as a response of the official bodies to the farmers’ request. Although it seems to be controversial, these changes allow minimizing the farmers’ time loss because an additional visit to the testing unit is not necessary. The risk of an unjustified exchange of components is relatively low because the farmer is able to verify the actual necessity during the inspection.

2.3 Test methods

The inspection methods and criteria were based on the European experience with some minor modification to our specific situation. Very helpful was also the personal assistance of our German, Belgian, Norwegian and Swedish colleagues (Ganzelmeier, 2002, Langenakens, 2003). The main aim of an expert group working on the inspection procedure was to adjust it as much as possible to the proposal of the European EN 13790 standards. The draft of this standard was the base for the essential rules of inspection in Poland. The specific situation of our agriculture was also taken into account and for that reason the inspection criteria are less restrictive at the moment. The simplest and cheapest methods of verification were chosen, to adjust our system to the economic situation of Polish agriculture. Some measurements were replaced by visual evaluation and functional tests. However, the methods and criteria of the test procedure can be easily adapted to EU standards, if necessary. The main differences in the methods of inspection are shown on tables 2 and 3.

### Table 2: The main differences in the criteria of sprayer inspection between EN 13790-1 standard (field crop sprayers) and the used methods in Poland

<table>
<thead>
<tr>
<th>Subject</th>
<th>EN 13790-1 standard</th>
<th>Criteria in Poland</th>
</tr>
</thead>
<tbody>
<tr>
<td>- tractor linkage</td>
<td>None</td>
<td>The sprayer should be mounted on/to the tractor properly</td>
</tr>
<tr>
<td>4.2.3 - Pressure safety valve</td>
<td>When there is a pressure safety valve on the pressure side of the pump, this valve shall work reliably</td>
<td>None</td>
</tr>
<tr>
<td>4.5.2 Measuring systems: pressure stability and repeatability</td>
<td>None</td>
<td>Deviation of 7 % at 3 bar</td>
</tr>
<tr>
<td>4.5.4 Pressure gauge: scale</td>
<td>At least 0.2 bar, working pressure less than 5 bar</td>
<td>At least 0.5 bar, working pressure less than 5 bar</td>
</tr>
<tr>
<td>4.5.6 Pressure gauge: accuracy</td>
<td>+/- 0.2 bar, working pressures less than 5 bar</td>
<td>+/- 10 %, working pressures 1, 3 or 5 bar</td>
</tr>
<tr>
<td>4.7.1 Filtering: mesh size</td>
<td>Shall correspond to the nozzles according to the instructions of nozzle manufacturers</td>
<td>Not smaller than the smallest size of nozzle mounted on the sprayer</td>
</tr>
<tr>
<td>4.8.11 Spray boom: pressure variation</td>
<td>... the pressure shall not vary more than 10 % when the sections are closed one by one</td>
<td>None</td>
</tr>
<tr>
<td>4.9.2 Nozzles: dripping</td>
<td>... the nozzle shall not drip more than 20 ml after the spray jet has collapsed if fitted with anti drip devices</td>
<td>... the nozzle shall not drip more than 20 ml after the spray jet has collapsed if fitted with anti drip devices</td>
</tr>
<tr>
<td>4.10.1 Nozzles: transverse distribution</td>
<td>CV=10 % and +/- 20 % deviation of spray liquid collected by each patternator groove</td>
<td>CV=15 % or the volume of collected spray liquid of 1.5% of the patternator groves and shall not deviate more than 15 % from average</td>
</tr>
<tr>
<td>4.10.2 Nozzles: flow rate</td>
<td>The deviation of the flow rate shall not exceed +/- 10% of nominal flow</td>
<td>The deviation of the flow rate ... shall not deviate +/- 10 % from average</td>
</tr>
<tr>
<td>4.10.2.2 Nozzles: pressure drop</td>
<td>Pressure drop shall not exceed 10 % of the pressure shown on the pressure gauge</td>
<td>None</td>
</tr>
</tbody>
</table>
### Table 3: The main differences in the criteria of sprayer inspection between EN 13790-2 standard (air – assisted sprayers for bush and tree crops) and the methods used in Poland

<table>
<thead>
<tr>
<th>Subject</th>
<th>Requirement</th>
<th>EN 13790-1 standard</th>
<th>Criteria in Poland</th>
</tr>
</thead>
<tbody>
<tr>
<td>- tractor linkage</td>
<td></td>
<td>none</td>
<td>the sprayer should be mounted on/to the tractor properly</td>
</tr>
<tr>
<td>4.2.3. Pressure safety valve</td>
<td>When there is a pressure safety valve ..... this valve shall work reliably</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>4.5.2. Measuring system: - pressure stability and repeatability</td>
<td>...tolerance of +/- 10% ...</td>
<td></td>
<td>deviation of 7% at 10 bar</td>
</tr>
<tr>
<td>4.5.6. Pressure gauge: - scale</td>
<td>at least 0.2 bar, working pressure less than 5 bar</td>
<td></td>
<td>at least 0.5 bar, working pressure less than 5 bar</td>
</tr>
<tr>
<td>4.5.8. Pressure gauge: - accuracy</td>
<td>+/- 0.2 bar, working pressures less than 5 bar</td>
<td></td>
<td>+/- 10%, working pressures at 5, 10 or 15 bar</td>
</tr>
<tr>
<td>4.7.1. Filtering: - mesh size</td>
<td>shall correspond to the nozzles according to the instructions of nozzle manufacturers</td>
<td></td>
<td>not smaller than the smallest nozzles mounted on the sprayer</td>
</tr>
<tr>
<td>4.8.3 Nozzles: - dripping</td>
<td>...the nozzles shall not drip 5 s after the spray jet has collapsed ....</td>
<td></td>
<td>...the nozzle shall not drip more than 20 ml after the spray jet has collapsed if fitted with anti drip devices ...</td>
</tr>
<tr>
<td>4.8.4 Nozzles: - switching of</td>
<td>It shall be possible to switch off each nozzle separately</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>4.8.5 Nozzles: - adjusting posit.</td>
<td>It shall be possible to adjust the position ..... in symmetric and reproducible manner</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>4.9.2 Nozzles: - output (symmetry)</td>
<td>...... the difference between the left and right sides mean output shall be a maximum of 10%</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>4.9.3 Nozzles: - pressure diff.</td>
<td>The pressure difference at each section inlet shall be a maximum of 15%</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>4.10.1. Blower: - rot. speed</td>
<td>The blower shall rotate at the speed specified by the manufacturer</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>4.10.3. Blower: - air g. plates</td>
<td>... air guide plates on the blower and ... on ..... blower casing shall function properly</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>4.10.4. Blower: - dripping</td>
<td>Parts of equipment shall not be sprayed ... and does not cause dripping</td>
<td></td>
<td>none</td>
</tr>
</tbody>
</table>

Only clean sprayers with protective guards can be tested. First, all the components of the sprayer are checked when the tractor’s engine is switched off. The tank with its cover, the strainer, pressure compensation and readability of the level indicator are verified. The operator must have an easy access to the drainage valve, including easy emptying of the tank and collecting liquid. The sprayer should be equipped with at least one filter on the suction side and one on the pressurised side. The strainer and nozzle filters can not be regarded as filters. The filters’ elements must be easily replaceable and be protected from damage. The hoses of the liquid system should not have any abrasions and bends. They should not disturb the spray pattern produced by the nozzles. The diameter and the scale of the manometer have to be checked.

The spray boom is one of the major parts of a field crop sprayer. Therefore, it has to be stable on all planes without any unwanted bouncing. The folding and unfolding of the boom section have to be easy. The boom has to be locked when in transport position. Excessive mechanical deformation and defects of
joins are not accepted. The distance from each individual nozzle to the target area should not deviate more than 10 cm. In field crop sprayers the type and size of the nozzles and the nozzle filters have to be identical. In orchard sprayers the layout of the nozzles has to be symmetrical in the right and left section. Measurements are checked and the visual inspection is carried through after the engine is switched on and PTO which connects tractor and sprayer is engaged. The pump capacity is evaluated by visual assessment of the agitation effect when the biggest nozzles are operated at maximum pressure. The accuracy of the manometer at three pressure ranges is evaluated of sprayers with the reference manometer mounted on the spray sections. If the failure rate in one of the measured ranges is higher than 10%, the manometer should be disassembled and additional measurements should taken on the stand. All valves of the operating unit should be working properly. The stability and repeatability of the pressure is measured. If the sprayer is equipped with anti drip valves they should work properly. The test method for nozzles depends on the type of sprayer. The flow test is carried out on orchard sprayers. Transverse distribution is measured to evaluate nozzles on field crop sprayers. Electronic and manual patternators provided with a groove of 100 mm are recommended. However, simple patternators with a groove of 50 mm are temporarily admitted, because about 60 Lurmark – type patternators were bought in Poland by the extension services. The CV % calculated by electronic patternator shall not exceed 15%. When a manual patternator with a 50 mm groove is used, only 15% of the measured tubes. The volume of collected spray liquid may deviate more than 15% from average. As an alternative a flow test for nozzles on field crop sprayer may be conducted. In this case, the actual flow rate of the nozzle shall not deviate more than 10% from the nominal value.

3. Results

From the beginning of inspection to the end of 2003 the number sprayers tested in Poland amounts to 98,862 (32.76%). During the first two years of inspection, i.e. by the end of 2001, only 9.4% of sprayers were tested. However, there are some regions in Poland where almost 80% of sprayers are officially approved. The main reason of the relatively low response from farmers was the short period for organising and training test staff and the relatively low financial support of the government for establishing the test units and for purchasing measuring equipment. This was not sufficient for establishing the voluntary inspection of sprayers “in use” and for the wide promotion of the advantages of inspection.

Great efforts were made by our Ministry of Agriculture as well as by the Plant Health and Seed Inspection Service to promote the advantages of inspection. A very positive response was obtained from the National Fund for Environmental Protection and Water Management to the program of modernising sprayers. In recent years the alliance for promoting obligatory inspection of sprayers “in use” was joined by the food processing industry. They check if their suppliers use PPP properly. They ask them for the spray application records and for the official documents confirming qualifications of the operator and the inspection of sprayers. The most active are the producers of chips and baby food. It is to be expected that the Integrated Agriculture Production, which becomes more and more popular in Poland will also stimulate the interest of farmers in the inspection of sprayers.

The typical defects of sprayers are more or less the same as in other countries. Excessively worn nozzles and damaged manometers are the most common defects. However, they can be easily replaced during the inspection. More complex repairs need to be done when the sprayer is poorly designed or has construction defects. Boom bending and poor stability occur very often in field crop sprayers. An incorrect nozzle configuration is also typically found in orchard sprayers.

Poor maintenance of sprayers was also a reason for rejection. Some sprayers were not clean and PPP residues were found in the filters. Several machines were not properly mounted on the tractor and a few were not equipped with the necessary protective guards. This goes to show that the knowledge of farmers regarding the influence of daily maintenance on the durability of the sprayer’s components and the quality of treatment is insufficient.

An increasing number of imported sprayers, new and second hand, can be found in Poland. It requires harmonisation of inspection methods for the mutual recognition of test results in order to simplify the use of these machines. However, common criteria have to consider the influence of the particular imperfections of components on the spray quality. In some cases they are too restrictive (CV for the
nozzles, scale of the manometers). Their influence on the quality of treatments in the field is so low in many cases that it can not be detected. They do not have any influence on the biological efficacy of the treatments and on environmental pollution by pesticides.

4. Conclusions

Polish first experiences in introducing the obligatory system of testing sprayers in use allow the following conclusions:

- The mandatory inspection of sprayers should be foregone by a voluntary inspection and by very intensive promotion activity. Co-operation with food processing plants, consumer organisations and farmers' unions is also necessary.
- The new sprayers meet the standards of inspection of sprayers in use and do not require inspection during their initial two (three) years,
- and to attract them to the inspection.
- The criteria of the inspection should be revised based on the real influence of defects on the quality of spray application and their effect on the biological efficacy.
- Harmonisation of test methods is necessary for mutual recognition of test results.

References


Testing of sprayers in Norway

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3) The Norwegian Food Safety Authority, Moervn. 12, N-1430, ÅS, Norway

Summary

Testing of crop sprayers and orchard sprayers started up voluntarily in 1991 and 1995 respectively. In 2000, the Norwegian parliament made the test mandatory. The requirements were simultaneously modified to raise the standard of the sprayers, and to promote better operator safety and handling. Examples of such requirements are flush tanks and flush nozzles for tanks of 600 litres or more, safe and simple handling of filters, improved solutions for emptying the tank, safe and simple handling of the regulation governing a boom height of 8 meters boom size and above, etc. In 2005 all sprayers will have to be approved. There are estimated to be about 12,000 crop sprayers in active use and, in addition, about 1,000 orchard mist sprayers. A total of about 10,000 sprayers, mainly crop sprayers, have been tested. Of these sprayers about 3,000 have been tested according to the mandatory requirements. The sprayers have to be tested every 5 years. About 70 testing trailers are scattered around the whole country to reduce transport costs. The farmer or grower himself has to partake in the test and is also instructed in how to calibrate the sprayer before every season. The test normally takes 2 hours, and the sprayers are mostly repaired and updated during the test. We have also started to develop a testing programme for spraying equipment in greenhouses, basically to ensure correct dosage. Testing of other crops and productions is also evaluated.

From 2004 testing of sprayers will also be a combined part of the educational programme for pesticide applicators. The EN 13790 standards and former proposals have been used to the greatest extent possible.

The Norwegian requirements will be presented in detail in the paper.

1. Introduction

Proper use of sprayers and a high standard of the spraying equipment are important factors to ensure an environmentally acceptable and precise spraying application. Therefore, a voluntary testing programme of sprayers in Norway started up for crop sprayers in 1990. Later, a voluntary testing programme for tractor-mounted orchard mist sprayers was initiated in 1995. The number of orchard sprayers is estimated to be only about 1,000, however, the risk of more drift, runoff and poorer spraying effects as well as a higher risk of pesticide residues, are more severe than for normal crop sprayers. Therefore there is an emphasis on testing these sprayers. This paper gives a short overview of the test equipment used, the test procedure, test results and further work needed.

2. Objectives

The function test in Norway consists of:

- Control of the sprayer.
- Repair of the sprayer.
- Informing the farmer / user about test results and how to calibrate the sprayer by using clean water.
- Motivate the farmer to get a better understanding and to properly use sprayers for application.

From our point of view, all these parameters have to be taken into account when evaluating the quality of a function test.

3. Testing equipment

Because of our special topographical and geographical conditions, and because one requirement is that the farmer himself shall partake in the test, more than 70 testing trailers offer the test.
The test trailer consists of:

- Tachometer (Jaquet, CH) to measure PTO revolution (0.02 %),
- Flow meter (Kytölä, SF) to measure pump capacity (4 %),
- Three reference manometers (Tempress, DK) (class 1.0) to measure the sprayer manometer,
- Patternator (Lurmark, UK) to measure boom distribution, 50 mm groove width,
- Equipment for measuring flow rates of orchard sprayers (Schachtner, D) (5 trailers),
- Jugs and/or nozzle flowmeters to measure nozzle capacity (Hardi, DK and TeeJet, US),
- Filter samples to determine filter mesh size,
- Washing facilities for the test operator,
- Safety package for demonstration,
- Testing protocols,
- Check lists,
- Spare parts (nozzles, filters, hoses, pipe lines, pumps etc).

4. Test procedure and requirements

4.1 In general

When the farmer contacts the test operator for the first time, basic information about type of sprayer, main function and standard of the sprayer is exchanged. The farmer has to clean the sprayer properly and test the sprayer with clean water to detect leakages and/or operating failures. This shall be reported back to the test operator beforehand. Thus the test operator can roughly calculate the required time and bring extra spare parts. The farmer is asked to fill the tank at least half way with clean water and to bring the tractor he normally uses when spraying. If possible, 3-5 farmers should meet at the same testing place but in many cases the test is carried out at every farm. Then the farmer does not need to travel long distances by tractor. The farmer has to partake in the test. Therefore, the farmer is more at ease, learns during testing and gets motivated to be more careful when applying pesticides by sprayer in future.
A test includes control of functionality and checking leakage of the sprayer. The pump capacity, the manometer exactness, the sprayer and boom construction and the stability and, last but not least, the control of the nozzles on the boom are measured. The distribution and the flow rate of every nozzle is measured. Most defects are eliminated during the test. The test takes on average 2 hours. The farmer, grower or user has to participate in the test to learn correct use and calibration of the sprayer. Before every season he is asked to do a test alone by using a checklist adapted to his needs. The function test shall be carried out at least every 5 years but the self-calibration shall be done every year. The function test as well as the check list includes a control of the driving speed. This is very much appreciated by the farmer. Frequently, mistakes in driving speed occur and have to be avoided.

4.2 Documentation

The farmer gets a copy of the test protocol as well as a checklist with the correct values for the first year. In addition a “Function test” label is attached to the sprayer as well as a “Registration” label to state that the sprayer is approved. A test protocol is shown in figure 2. The protocol may be filled out digitally. In this way necessary calculations are made automatically.

4.3 Requirements

Requirements are constantly developed according to progress made in sprayer development. In Dec. 2000 the parliament decided to make the test mandatory for crop sprayers as well as for orchard sprayers. To ensure an improved standard of the new sprayers in Norway, the requirements were made stricter for new sprayers bought after 1/1-2001. This was especially due for components expensive to fit in older sprayers but easy to install in new sprayers as standard. Such requirements were made initially because of better environmental solutions available but also because of increased spraying quality. Examples of such requirements are flush tanks and flush nozzles (of tank size over 600 litres) and safe and simple handling of:

- Filters,
- emptying of the tank,
- regulation of boom height (8 meters and more).

In this way newer sprayers have a better standard which motivates farmers. The farmers are, of course, free to install even more sophisticated solutions, such as remote control, pesticide filling devices, etc.

Table 1 and 2 show the requirements for crop sprayers in detail. The EN standards are included as far as possible. In addition to the requirements, test instructions are drawn up to ensure a more harmonised testing procedure and give more detailed information, particularly on special spraying equipment and/or on components and use. If necessary, it is probably easier to modify these instructions than the officially presented requirements.

4.4 Economy

The test costs about 215 € - extra spare parts, extraordinary long transport and labour, etc. have to be added. An amount of 85 € is paid by the government to subsidise the test. This amount was fixed since the beginning of 1991 and been changed only recently. From 1 January 2006 the test operator will receive 50% of the costs (maximum limit 3,500 €), covered by the government.

4.5 Instruction of the farmer

During the test, the farmer is instructed in the correct use and calibration of the sprayer. Single nozzle sheets for the most common types are drawn up according to the BCPC standards. The farmer can find the recommended spray quality for the most common spray tasks on the back of the data sheet. The focus is on how to improve the deposit and on lower drift.

In addition to testing the sprayer every 5 years, the users of pesticides in Norway have to have an authorisation to be renewed every 10 years by attending a course which comprises all aspects of spraying application, including biological and toxic factors. The government decided that from 2004 the function test shall be part of this training to improve the technical content. This ensures that the farmer receives co-ordinated information, a more individual training, more frequent education in spraying techniques, a
better overview and increased motivation. To support teachers as well as the testing operator to fulfil these tasks, a CD containing pictures, video-clips, technical data, calibration sheets and other support is available in addition to traditional booklets. The CD will be briefly introduced at the conference. For the future it is envisaged to update its content via internet. The CD covers only crop sprayers but similar solutions are also planned for other types of spraying equipment, e.g. in orchards and greenhouses.

4.6 Education of test operators

The education of test operators is carried out by the Department of Mathematical Sciences and Technology at the Agricultural University of Norway under the authority of the Norwegian Food Safety Authority. The operators who are carrying out the test come from official bodies as well as from private workshops. They have to renew their authorisation every 5 years.

5. Results

Figure 2 presents the test results in the period 1991 to 2003.

The figure illustrates that there was a large amount of interest in testing in the beginning. In the middle of the 1990s the participation went down. During the period 1993-1999 there was much discussion about making the function test mandatory. This was finally decided on in 2000. The reason why the participation in testing is still moderate may be that the final deadline for testing the sprayers is 2005. Therefore we expect a higher number of sprayers to be tested this year and the next.

Figure 2: Number of sprayers tested in the period 1991 to 2003.
Table 3: Results from a survey of 520 crop sprayers. Overview of failures repaired even if rejected.

<table>
<thead>
<tr>
<th>Components</th>
<th>Number</th>
<th>%</th>
<th>Components</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning</td>
<td>3</td>
<td>0.3</td>
<td>Cleaning</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Pressure accumulator</td>
<td>8</td>
<td>0.9</td>
<td>Pressure accumulator</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Leaks</td>
<td>70</td>
<td>8.1</td>
<td>Leaks</td>
<td>5</td>
<td>10.4</td>
</tr>
<tr>
<td>Pump</td>
<td>20</td>
<td>2.3</td>
<td>Pump</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Agitation</td>
<td>0</td>
<td>0.0</td>
<td>Agitation</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Manometer</td>
<td>156</td>
<td>18.0</td>
<td>Manometer</td>
<td>8</td>
<td>16.7</td>
</tr>
<tr>
<td>Pressure drop</td>
<td>0</td>
<td>0.0</td>
<td>Pressure drop</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Operating device</td>
<td>15</td>
<td>1.7</td>
<td>Operating device</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Tank &amp; filling</td>
<td>7</td>
<td>0.8</td>
<td>Tank &amp; filling</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Hand wash tank</td>
<td>140</td>
<td>16.2</td>
<td>Hand wash tank</td>
<td>4</td>
<td>8.3</td>
</tr>
<tr>
<td>Hoses &amp; pipes lines</td>
<td>46</td>
<td>5.3</td>
<td>Hoses &amp; pipes lines</td>
<td>2</td>
<td>4.2</td>
</tr>
<tr>
<td>Filter suction side</td>
<td>25</td>
<td>2.9</td>
<td>Filter suction side</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Filter pressure side</td>
<td>28</td>
<td>3.2</td>
<td>Filter pressure side</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Distribution</td>
<td>0</td>
<td>0.0</td>
<td>Distribution</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Nozzles</td>
<td>187</td>
<td>21.6</td>
<td>Nozzles</td>
<td>11</td>
<td>22.9</td>
</tr>
<tr>
<td>Nozzle filters</td>
<td>62</td>
<td>7.2</td>
<td>Nozzle filters</td>
<td>6</td>
<td>12.5</td>
</tr>
<tr>
<td>Boom</td>
<td>9</td>
<td>1.0</td>
<td>Boom</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>Handling</td>
<td>2</td>
<td>0.2</td>
<td>Handling</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Power Take Off</td>
<td>38</td>
<td>4.4</td>
<td>Power Take Off</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>Emptying device</td>
<td>8</td>
<td>0.9</td>
<td>Emptying device</td>
<td>2</td>
<td>4.2</td>
</tr>
<tr>
<td>Equal pressure device</td>
<td>0</td>
<td>0.0</td>
<td>Equal pressure device</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Boom height regulator</td>
<td>0</td>
<td>0.0</td>
<td>Boom height regulator</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Flushing system</td>
<td>0</td>
<td>0.0</td>
<td>Flushing system</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Failures in total 865 100.0 Failures in total 48 100.0

The failure rate of approved sprayers was on average 1.75. Also the sprayers which were not approved of were greatly improved, especially by fitting new nozzles and improving spraying quality. Small sprayers were not always equipped with a hand wash tank and anti-drip device. The distribution failures are equal to zero. This does not mean that any of the sprayers did not show poor distribution before the test, however, the value shows that sprayers were improved under every circumstance by cleaning and/or exchanging nozzles. This is illustrated by the high number of sprayers with nozzle failures. This means that most farmers are highly motivated and focused on good nozzles and a correct dose. In contrast, environmental factors will have to be even more highlighted.

6. Conclusions

The function test has been carried out for 14 years and regarding crops sprayers and orchard sprayers for 9 years. All sprayers have to be tested in 2005. The testing units consist mostly of testing trailers which are mobile solutions. In this way, the test can be carried out in the field or directly on the farm. One important requirement is that the farmer or grower has to participate in the test. In addition, a check list is drawn up by which users learn how to calibrate the sprayers on their own every year.

The requirements in the Norwegian test procedure differ in some areas from the EN standards because the test was established in 1991 and requirements were last updated in 2000. In addition, the system is based on a few tests per test locality for which i.e. the Lurmark patternator is the best solution. Unlike
many other countries, the driving speed is always measured because errors cause wrong dosage immediately. As from 2004 the information and motivation during a function test is even more highlighted.

The Norwegian test also has very many test requirements similar to the EN standards, and in future we will work on harmonising the procedures even further. However, a light and simple patternator for testing of conventional crop sprayers will continue to be the most widely used solution in the years to come.

Acknowledgements

The authors wish to acknowledge The Norwegian Food Safety Authority for the financial support of this project.

References


Enclosures

1. Norwegian requirements for crop sprayers. Please note the different requirements for new sprayers before and after 1 January, 2001.
Minimum requirements for CROP SPRAYERS bought before 01.01. 2001

<table>
<thead>
<tr>
<th>Components</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>No leaking shall occur from any part of the sprayer</td>
</tr>
<tr>
<td>Pump</td>
<td>No coarse pulses. Minimum pump capacity measured at 540 rpm and 8 bars shall cover the largest flow rate needed (regarding nozzle size and nozzle pressure) and 10% in addition. During hydraulic agitation the pump capacity shall be at least 5% of tank capacity in litres/min</td>
</tr>
<tr>
<td>Agitation</td>
<td>Proper agitation for different needs.</td>
</tr>
<tr>
<td>Manometer</td>
<td>Easy and correct read off values with adapted scaling and pressure interval. Max. deviation ± 0.5 bars in the interval of 1 to 8 bars. (± 1.0 bar over 8 bars)</td>
</tr>
<tr>
<td>Pressure drop</td>
<td>Max. deviation between manometer and nozzles shall be less than 10 % of the manometer value (corrected value).</td>
</tr>
<tr>
<td>Valve control</td>
<td>Control of devices very precisely. Easy handling. Every section shall be operated separately.</td>
</tr>
<tr>
<td>Tank</td>
<td>Equipped with tank sieve. Good cover ventilation. Safe emptying device*). Easy and exact read off from the scaling in litres.</td>
</tr>
<tr>
<td>Filling device</td>
<td>Filling device that prevents any return of fluid.</td>
</tr>
<tr>
<td>Hand wash tank</td>
<td>Min. 10 l tank mounted on the sprayer.</td>
</tr>
<tr>
<td>Filtering</td>
<td>There shall be at least one filter both on the suction and on the pressure side. Easy handling without any risk of exposure *). The meshes of the last filter on the pressure side should not be bigger than the nozzle opening.</td>
</tr>
<tr>
<td>Distribution</td>
<td>Deviation within ± 20 % from the average, measured stationary along the boom (for 50 mm patterneror spacing which is most commonly used in Norway) and ± 15 % for 100 mm spacing). This is measured at a nozzle height of 40 cm and working pressure of 2.0 bar for flat fan nozzles 110-120. For air injection nozzles a height of 50 cm and a pressure of 5.0 bar shall be used.</td>
</tr>
<tr>
<td>Anti drip device</td>
<td>No dripping is accepted.</td>
</tr>
<tr>
<td>Nozzles</td>
<td>The nozzle uniformity shall have a capacity within ±8 % of the average value. The nozzle wear and tear shall not be more than 10 % (flow rate in regard to new nozzles). The nozzle filters and anti drip device shall be of equal type for all nozzles.</td>
</tr>
<tr>
<td>Boom stability</td>
<td>Good stability in vertical and horizontal direction. Measured stationary the boom height shall not deviate more than ± 1 % from the boom width. For a 10-meter boom that means ± 10 cm. The boom shall be controlled in working and in transport position. Nozzles or hoses shall not be injured, pressed or turned out of position when the boom is folded together.</td>
</tr>
<tr>
<td>Boom safety</td>
<td>The boom shall be locked in a safe transport position.</td>
</tr>
<tr>
<td>Control</td>
<td>Fluid hoses inside the cabin are forbidden. PTO shall not be used for opening/closing of the fluid to the boom.</td>
</tr>
<tr>
<td>Power take out</td>
<td>The cover shall be in good condition and properly fixed (not rotating).</td>
</tr>
</tbody>
</table>

*) For sprayers without any possible technical means for meeting these requirements, the user/owner shall be instructed in proper use of protecting safety and how to avoid the risk of exposure.
## Minimum requirements for new CROP SPRAYERS bought after 01.01.2001

<table>
<thead>
<tr>
<th>Components</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump</td>
<td>For conventional crop sprayers designed for up to 400 l/ha, the pump must deliver at least 2.5 l/min and m boom.</td>
</tr>
<tr>
<td>Nozzles</td>
<td>Nozzle colour and nozzle size according to ISO/CEN standard and bayonet fittings.</td>
</tr>
<tr>
<td>Uniformity</td>
<td>Single nozzle output uniformity below ±5%</td>
</tr>
<tr>
<td>Nozzle sheet and operator manual</td>
<td>Nozzle sheet for the nozzles mounted to the boom should be in line with the sprayer together with Norwegian recommendations.</td>
</tr>
<tr>
<td>Manometer</td>
<td>Maximum deviation of ≤ 0.20 bar in the range from 0 - 8 bar.</td>
</tr>
<tr>
<td>Main tank</td>
<td>The emptying valve shall be operated safely without any risk of exposure.</td>
</tr>
<tr>
<td>Agitation</td>
<td>The sprayer shall be equipped with adjustable agitation to be operated in at least two steps.</td>
</tr>
<tr>
<td>Filtering</td>
<td>The sprayer shall be fitted with filters that can be operated with minimum risk of exposure. It shall be possible to operate the filters in spite of fluid in the main tank</td>
</tr>
<tr>
<td>Hand wash tank</td>
<td>Fixed mounted hand wash tank on the sprayer which has a volume of at least 15 litres.</td>
</tr>
<tr>
<td>Regulation of boom height</td>
<td>For sprayers with boom width equal to or larger than 10 m, the boom height shall be adjusted in a proper, easy and safe way by one person.</td>
</tr>
<tr>
<td>Equal pressure device</td>
<td>The operator control shall be equipped with an equal pressure device, that ensures constant nozzle pressure independent of sections in use.</td>
</tr>
<tr>
<td>Flush nozzle and flush tank</td>
<td>A tank with content over 600 litres shall be equipped with a flushing nozzle together with a separate washing tank.</td>
</tr>
<tr>
<td>Calibration kit</td>
<td>A calibration kit for nozzle measurement (jugs with good scaling in the range of 1.5-2.0 litres) shall come with the new sprayer as well as a cleaning tool for nozzles.</td>
</tr>
</tbody>
</table>
## Minimum requirements for ORCHARD SPRAYERS bought before 01.01.2001

<table>
<thead>
<tr>
<th>Components</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td>No leaking shall occur from any part of the sprayer</td>
</tr>
<tr>
<td><strong>Pump</strong></td>
<td>No pulsing; even flow. Minimum rate: Nozzle rate measured at 10 bar of nozzle type installed + 10 % and a minimum of 25 litres/min. In addition, 5 % of tank volume for agitation in litres/min.</td>
</tr>
<tr>
<td><strong>Agitation</strong></td>
<td>Agitation shall have a proper visual function for different demands</td>
</tr>
<tr>
<td><strong>Manometer</strong></td>
<td>Easy and correct read off values (adapted scaling and pressure interval), Max. ±10 % deviation in the range from 1 to 20 bar and ± 5.0 bar above 20 bar pressure.</td>
</tr>
<tr>
<td><strong>Pressure drop</strong></td>
<td>Deviation between manometer and nozzles less than 10 % of manometer value (corrected value)</td>
</tr>
<tr>
<td><strong>Valves, operation control</strong></td>
<td>Operation control of precision and no leaking. Easy handling. Each nozzle side shall be operated separately.</td>
</tr>
<tr>
<td><strong>Tank</strong></td>
<td>No leaking from tank and connections. Equipped with tank sieve. Ventilated cover. Safe emptying device*). Easy and exact read off from the tank scale in litres</td>
</tr>
<tr>
<td><strong>Filling device</strong></td>
<td>Filling device that prevents any return of fluid</td>
</tr>
<tr>
<td><strong>Emptying of tank</strong></td>
<td>The emptying valve shall be operated in a safe way without any risk of exposure *).</td>
</tr>
<tr>
<td><strong>Hand wash</strong></td>
<td>Tank with minimum volume of 10 litres fixed on the sprayer</td>
</tr>
<tr>
<td><strong>Filtering</strong></td>
<td>At least one filter on the suction side. Easy handling and demounting without any risk of exposure. Last filter shall not have bigger meshes than the nozzle opening.</td>
</tr>
<tr>
<td><strong>Nozzles, uniformity, skewness / symmetry, equal pressure device</strong></td>
<td>The difference between the left and the right side and half of the total flow rate shall be less than ± 5 %. The nozzles should not be guided more than 25° upwards. Pressure shall not deviate more than ± 25 % when closing the flow on one side. The user is instructed in adjusting the correct pressure.</td>
</tr>
<tr>
<td><strong>Anti drip device</strong></td>
<td>No dripping is accepted. Where it is technically possible to update an anti drip device, such device shall be mounted. Same type of nozzle filter and anti drip device should be installed on all nozzles.</td>
</tr>
<tr>
<td><strong>Nozzles</strong></td>
<td>Nozzles of same size shall not deviate more than ± 10 %. Nozzle wear and tear shall give less than 10 % increase compared to new nozzles at the same pressure.</td>
</tr>
<tr>
<td><strong>Remote control not to be used</strong></td>
<td>Hoses transporting spray fluid shall not be brought into the driver’s cabin. The PTO shall not be used for opening and closing the fluid.</td>
</tr>
<tr>
<td><strong>Top air guidance</strong></td>
<td>Axial fan mist blowers shall be equipped with proper top air guidance</td>
</tr>
<tr>
<td><strong>Fan and air distribution</strong></td>
<td>The fan shall work properly up to 600 rpm at the PTO. No damage, unbalance or vibration shall occur. The fan blades shall be symmetric, well fixed and without damages.</td>
</tr>
<tr>
<td><strong>Fan and security</strong></td>
<td>The fan shall be properly secured including fixed, undamaged and sufficient guard in front of the air inlet.</td>
</tr>
<tr>
<td><strong>Power take off</strong></td>
<td>The guard shall not be damaged and be properly fixed.</td>
</tr>
</tbody>
</table>

* For sprayers without any possible technical means for meeting these requirements, the user/owner shall be instructed in proper use of protecting safety and how to avoid the risk of exposure.
### Minimum requirements for ORCHARD SPRAYERS bought after 01.01.2001

<table>
<thead>
<tr>
<th>Components</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump</td>
<td>Minimum rate: Nozzle flow rate measured at 10.0 bar of nozzle type installed + 20%. In addition, 5% of tank volume for agitation</td>
</tr>
<tr>
<td>Agitation</td>
<td>Agitation capacity: a minimum of 5% of the volume of the tank in litres/min. Agitation capacity should have a minimum of two steps</td>
</tr>
<tr>
<td>Nozzles</td>
<td>Nozzles according to ISO/CEN standard (colour and size)</td>
</tr>
<tr>
<td>Uniformity</td>
<td>The deviation between nozzles shall be at the most ± 5%</td>
</tr>
<tr>
<td>Anti drip device</td>
<td>No dripping is accepted.</td>
</tr>
<tr>
<td>Manometer</td>
<td>No deviation above ± 0.20 bar in the range of 0 – 8 bar. Read off accuracy of 0.2 bar or preferably in the range of up to 15 bar</td>
</tr>
<tr>
<td>Individual closing of nozzles</td>
<td>It should be possible to close and open the upper two nozzles and the lower nozzle on each side easily and individually.</td>
</tr>
<tr>
<td>Data leaflets and directions for use</td>
<td>The directions for use should be adjusted to the use in Norway regarding requirements, practical suggestions and equipment for the sprayer.</td>
</tr>
<tr>
<td>Tank</td>
<td>The emptying valve shall be operated safely without any risk of exposure. The content shall be read off at an exactness of 25 litres. The tank shall collect foam and have a smooth inner surface without sharp corners.</td>
</tr>
<tr>
<td>Filtering</td>
<td>At least one filter, both on the suction and on the pressure side. Filters may be changed without any risk of exposure and in spite of fluid in the tank.</td>
</tr>
<tr>
<td>Hand wash tank</td>
<td>Fixed mounted hand wash tank on the sprayer which has a volume of at least 15 litres.</td>
</tr>
<tr>
<td>Flush tank</td>
<td>A tank containing more than 600 litres shall be equipped with a separate flush tank.</td>
</tr>
<tr>
<td>Equal pressure device</td>
<td>The operator control shall be equipped with an equal pressure device to ensure constant nozzle pressure independent of sections in use.</td>
</tr>
<tr>
<td>Easy replication of nozzles and air flow</td>
<td>The sprayer shall be marked in such a way that the adjustments of nozzles and air distribution shall be easily replicated. The adjustment of nozzles and air must be easy and secure.</td>
</tr>
<tr>
<td>Calibration kit</td>
<td>A calibration kit for nozzle measurement and cleaning tools for nozzles shall be in line with the new sprayer. Hoses that can be connected to all the nozzles at the same time for simple and secure measuring of nozzle capacity, without having to use tools, shall follow.</td>
</tr>
</tbody>
</table>
# Test protocol used in Norway (digital edition)

## TEST OF CROP SPRAYERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test operator, company, address, phone, fax etc</td>
<td></td>
</tr>
<tr>
<td>Date and year</td>
<td>Location</td>
</tr>
<tr>
<td><strong>1. PUMP</strong></td>
<td></td>
</tr>
<tr>
<td>Pressure in bars</td>
<td>Measured cap. l/min</td>
</tr>
<tr>
<td>Free flow</td>
<td>2.0</td>
</tr>
<tr>
<td>Measured capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer information</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Largest nozzle size in use</td>
<td>Max press. bar gives l/min nozzle*</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure in bars</td>
<td>Measured cap. l/min</td>
</tr>
<tr>
<td>Free flow</td>
<td>2.0</td>
</tr>
<tr>
<td>Measured capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer information</td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Largest nozzle size in use</td>
<td>Max press. bar gives l/min nozzle*</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2. MANOMETER</strong></td>
<td></td>
</tr>
<tr>
<td>Reference manometer</td>
<td>Sprayer manometer</td>
</tr>
<tr>
<td>1.0 bar</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>3. NOZZLES</strong></td>
<td></td>
</tr>
<tr>
<td>Nozzle type</td>
<td>Pressure (bars)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4.1 PROPER CLEANED</strong></td>
<td></td>
</tr>
<tr>
<td><strong>5.1 NO LEAKS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>6.1 TANK AND FILLING</strong></td>
<td></td>
</tr>
<tr>
<td><strong>7.1 SPRAYOR DEV.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>8.1 PULS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>9.1 FILTER PRESSURE SIDE</strong></td>
<td></td>
</tr>
<tr>
<td><strong>10.1 NOZZLE WEAR &lt; 10%</strong></td>
<td></td>
</tr>
<tr>
<td><strong>11.1 NOZZLE FILTER</strong></td>
<td></td>
</tr>
<tr>
<td><strong>12.1 NO DRI PPING</strong></td>
<td></td>
</tr>
<tr>
<td><strong>13.1 TANK REG. (2001+)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>14.1 HAND-REJ. TANK</strong></td>
<td></td>
</tr>
<tr>
<td><strong>15.1 REFRIGERA TION</strong></td>
<td></td>
</tr>
<tr>
<td><strong>16.1 POWER TAKE OFF</strong></td>
<td></td>
</tr>
<tr>
<td><strong>17.1 SPRAYERS REJECTED CAUSED BY:</strong></td>
<td></td>
</tr>
</tbody>
</table>

*For sprayers bought before 2001.01.01 approved when uniformity is below +8%.
Inspection of sprayers in Germany – results and experience over the past decades

OSTEROTH, H.-J.
Federal Biological Research Centre for Agriculture and Forestry, Messeweg 11/12, D-38104 Braunschweig, Germany

Summary

Voluntary inspections of field sprayers have been offered in the Federal Republic of Germany since the end of the sixties and for air-assisted sprayers for orchards, vineyards and hops since the mid eighties. As a result, Germany has gathered plenty of experience with the inspection of plant protection equipment. The inspections were based on uniform inspection requirements (BBA Guideline 1-3.2.1) and are carried out in about 1000 recognised workshops in about 2000 places. Workshops must be officially approved and use in most cases test facilities which have been approved by the BBA. Up to 1993 around 30 000 sprayers were inspected every year; in the meantime -after the introduction of the obligatory inspection of field sprayers in 1993- the number of inspected sprayers has increased to about 63 000 per year. The inspection fee for field sprayers increased from 40 € per inspection in the year 1992 to 130 € in the year 1994 and to at last 145 € in the year 2003. Dripping nozzles, faulty manometers and unsatisfactory distribution were often the reason for not meeting minimum requirements. Future activities will be harmonising the national sprayer inspection with the European norm EN 13790.

1. Introduction

<table>
<thead>
<tr>
<th>Timeline - Inspection of sprayers in Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>End of the sixties to the beginning of the seventies</strong></td>
</tr>
<tr>
<td>1970</td>
</tr>
<tr>
<td>1976 voluntary</td>
</tr>
<tr>
<td>1983</td>
</tr>
<tr>
<td>1993 obligatory</td>
</tr>
<tr>
<td>2002</td>
</tr>
<tr>
<td>2003</td>
</tr>
</tbody>
</table>

Figure 1: Timeline – Inspection of sprayers in Germany.

Already in 1970 the first test facilities for the testing of field sprayers were available. Still, from the beginning, all inspections were based on uniform inspection requirements throughout Germany which were published in BBA - leaflet 44. The guideline contains requirements for inspection, a code of inspection, an example of an inspection protocol, an example of a control label and a kind of code for approval of workshops. Workshops for agricultural equipment were and still are recognised workshops where the inspections are carried out on a regular basis. At present there are about 1000 inspection workshops which inspect plant protection equipment in about 2000 places. These inspection workshops
are officially approved by the official plant protection authorities of the federal states ("Länder") in accordance with the code of approval.

![Diagram](image)

Figure 2: Workshop of the BBA – leaflet 44 with the target of uniform inspections and comparable results.

The approved workshop must be able to show evidence of trained personnel and perform the inspections according to a uniform code of inspection. In most cases, only test facilities which have been approved by the BBA for the respective measuring task are used for the inspections.

2. The situation today – results and experience

![Diagram](image)

Figure 3: Situation today – Obligatory inspection in Germany.
In the year 1983 the voluntary inspection of air-assisted sprayers started and changed to an obligatory inspection in the year 2002. The requirements for plant protection equipment already in use (Guideline 1-3.2.1 'Features for testing field sprayers and air-assisted sprayers already in use') were established by a working group consisting of representatives at the official plant protection service from the various federal states led by the BBA. These requirements are constantly adjusted to meet new technological developments and were last amended in December 2001. The BBA guideline 1-3.2.1 contains the main features for testing field sprayers and air-assisted sprayers already in use. 

Sprayer parts to be tested are

- Drive - protection device for power transmission.
- Pump - capacity, leakage, pulsation, pressure-relief device.
- Agitator - clearly visible agitation.
- Tank – no leakage, strainer in the tank dome, filling devices, collection at the outlet.
- Controls – no leakage, function, readable during work, pressure gauge – accuracy.
- Pipe-system – no leakage, no marks of bending.
- Filtering – suction filter, pressure line filter.
- Spray boom – stable design, no deformation or deflection, no liquid shall be sprayed onto the sprayer itself.
- Nozzles – all nozzles the same type, no dripping, cross distribution.
- Blast – no deformation or corrosion.

Figure 4: Number of inspections and total number of field sprayers in Germany.

Following the introduction of the obligatory inspection for field sprayers in 1993 and for air-assisted sprayers in 2002, there was a sudden increase in the total amount of inspections carried out. Up to 1993,
around 30 000 field sprayers were inspected; in the meantime, this number has increased to almost 63 000 per year. With the introduction of the obligatory inspection a transition period of 3 years took place. Sprayers which are inspected in 1993 have got a period of 3 years until the next cycle. The transition period is the reason for the big increase of the inspection numbers in the year 1996 and in the following two-year periods (1998, 2000 and 2002). The effect of the structural change in farming (number of farms decrease and farm areas increase) may be the reason for the decrease of total numbers of field sprayers in Germany from 170 000 in the year 1986 to 130 000 sprayers in the year 2003.

For air-assisted sprayers, the extent of inspections remained fairly constant over the years at around 3000 inspections per year. However, it is expected that, because inspections have been compulsory since 2002, there will be a definite increase in the number of inspections carried out annually in the years to come.

Figure 5: Average inspection fee for field sprayers.

The inspection fee for field sprayers increased from 40 € per inspection in the year 1992 to 130 € in the year 1994 (after introduction of compulsory inspections) to at last 145 € in the year 2003. One reason for the increased inspection fee may be, that the inspection workshops invested in new test facilities, for example, equipment for measuring the cross distribution.

Originally, dripping nozzles, faulty manometers and unsatisfactory distribution were often the reason for not meeting minimum requirements; today this is also often due to controls, pipe systems and spray booms.
Figure 6: Defects of field sprayers 1993 in relation to 2003.

The measuring of the cross distribution is in Germany a central instrument to guarantee the spray quality and the chemical application later on in the field. Defects at the cross distribution decreased continually to at least round about 15% of the inspected sprayers. The knowledge and the training of farmers are going to be better and nozzles with poor spray quality are changed earlier than 20 years ago.

Figure 7: Cross distribution defects.
3. Conclusions

Basis for the inspections in Germany is the Plant Protection Act with the ordinance. A working group with members of the BBA and official authorities of the German federal states work out requirements for facilities and features for testing sprayers already in use. Inspection workshops must be recognised corresponding to the code of approval and carry out the inspections in accordance with the code of inspection. Inspected sprayers can reduce the environmental contamination, improving the biological efficiency and guarantee the chemical application in a proper way and also the intended use.

Future activities will be concentrated on harmonising national sprayer inspections with the European norm EN 13790. The necessary legal conditions already exist in Germany so that inspections carried out in the EU Member States and candidate countries in accordance with EN 13790 are also acceptable in Germany.

References
BBA-Merkblatt 1-3.2.1. Merkmale für die Prüfung in Gebrauch befindlicher Spritz- und Sprühgeräte für Flächen- und Raumkulturen.
Inspections of sprayers in use in Catalonia (Spain)

GRACIA, F.; ESCOLÀ, A.; BUSTOS, A.
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Centre de Mecanització Agrària - Rovira Roure, 191 - 25198 Lleida

Summary

Since 1985, the Centre of Agricultural Mechanisation of the Agricultural, Livestock and Fisheries Department of Catalonia is carrying out a programme of inspection of sprayers in use. This programme has been continuously adapted to the inspection standards. Today, voluntary inspections for field crop and air-assisted sprayers for tree crops are carried out complying most of the requirements of the EN 13790/1 and 2 standards.

Nowadays, a mandatory inspection programme of sprayers in use is being designed. The estimated number of sprayers in use in Catalonia is more than 30,000.

1. Introduction

In 1985, the Centre de Mecanització Agrària (Centre of Agricultural Mechanisation) of the Agricultural, Livestock and Fisheries Department from the regional government of Catalonia (North-East of Spain) started a programme to improve the efficiency of applications and to reduce the doses of chemicals. This programme consisted of a voluntary revision and a calibration of the sprayers in use and lasted about 10 years.

In 1995, revisions turned into inspections and calibrations were given up. New inspections evolved with changes in the visual inspection and in the verification of nozzle flow rate.

In 2000, changes were made to match the requirements of the first prEN 13790 drafts. Today, voluntary inspections for field crop and air-assisted sprayers for tree crops are carried out complying most of the requirements of the EN 13790 standard. Technical information and results are provided to farmers for them to know their sprayer state.

2. Materials and Methods

Inspections in Catalonia are made in an experimental way with a mobile unit to specify the way that future mandatory inspections will be done (Figure 1).

Figure 1: Mobile unit for inspections in Catalonia.

In an inspection process, a preliminary inspection is performed based in checking the security of the sprayer to be tested paying attention to the cleanliness and in the safety guards. If the sprayer is rejected in the preliminary inspection, the inspectors will not continue and the inspection is finished.
If passed, next step is the visual inspection with the PTO off to inspect requirements that do not need movement and the pressure gauge is tested. When finished, the PTO is connected to check the rest of the requirements.

After the visual inspection, the distribution is tested by checking the individual output of each nozzle and the pressure difference (sprayers for bush and tree crops) and pressure drop (field crop sprayers) according to EN 13790.

A complete report with all technical information and measurements is provided to farmers for them to know the state of their sprayers. The report consists in 3 documents. First one is a certificate of the inspection with all the checked parts with check boxes showing if there is a defect and if it is minor or critical. Second document is a complete detail of all measurements done during the inspection. And the last document is an explanation in clear sentences of the defects found in the inspection and a possible cause and reparation proceeding.

### 3. Results

Results shown in this section are from inspections done in the period where inspections are performed following the EN 13790 standard (from 2001). Most inspections in this period have been done in orchard sprayers (Figure 2).

Most of detected defects are found in pressure differences, nozzles and pressure gauge testing. These defects are present in more than 60% of sprayers inspected for the first time (Figure 3).

First inspections are passed only by about 50% of sprayers while second inspections are passed most of the sprayers (Figure 4).

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**Figure 2**: Global results of approved and rejected sprayers from 2001 (left). Percentage of type of sprayers inspected (right).

**Figure 3**: Global detected defects (left). Detected defects in first inspection (right).
5. Conclusions

Inspections make possible to know the maintenance condition of the sprayers in Catalonia and to check the presence of safety elements. Most sprayers pass the preliminary inspection, this is a consequence of the work done in previous revision programmes by the Centre of Agricultural Mechanization. If EN 13790 requirements would be applied strictly, much less sprayers would be approved in inspections. There is an important previous work to be done with sprayer manufacturers and with users. The formers should assure their products could pass an inspection just exiting the factory by producing according to EN 907 and EN 12761 standards. The latters should maintain their sprayers in good conditions following manufacturer’s instructions and changing worn parts.

The technical information obtained from the inspection of sprayers in use in Catalonia helps in the preparation of information leaflets with advices and improvements to be made in sprayers to assure their good maintenance conditions. This information is also a good way to know the number of sprayers in use and their characteristics (type of sprayer, pump, elements, materials,…).

Nowadays, a mandatory inspection programme for sprayers in use is being designed in Catalonia. The estimated number of sprayers in use in Catalonia is 30,000 sprayers.

Acknowledgments

Special thanks are given to all the staff that has participated in the inspections during all these years.
Inspection of field sprayers in Estonia – overview

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Estonian Research Institute of Agriculture (ERIA), Teaduse 13, EE-75501 Saku, Harjumaa, Estonia

According to the “Plant Protection Act” (enforced in 2000, amended in April 2004)

Requirements applicable to plant protection equipment:

- Plant protection equipment and manners of use thereof shall be harmless to human health and the environment and shall conform to the requirements provided for in the “Plant Protection Act” and other legislation.
- The conformity of plant protection equipment shall be certified by a declaration of conformity (copy) or by a certificate of conformity issued on the basis of the testing.
- A declaration of conformity of plant protection equipment need not be submitted with regard to spray guns and knapsack sprayers or if the equipment is used for research, in testing or as a sample.
- Environmental safety requirements and safety requirements for the use, storage and cleaning of plant protection equipment are established (shall be updated) by regulations of the Minister of Agriculture.
- It is prohibited to use plant protection equipment not meeting to requirements of the “Plant Protection Act”.
- The manufacturer, importer or distributor of plant protection equipment is required to notify the Plant Production Inspectorate of its activities in writing.
- The user manual in Estonian and the description of the type of the equipment and other documents which characterise the equipment shall be appended to the copy of the declaration of conformity of plant protection equipment.
- If a supervisory official discovers that plant protection equipment does not conform to the requirements, of the “Plant Protection Act”, a supervisory official may send plant protection equipment to testing, for the assessment and certification of conformity thereof.
- According to the “Plant Protection Act” the testing institution in Estonia is the Estonian Research Institute of Agriculture.
- The procedure for the testing of plant protection equipment shall be established by a regulation of the Minister of Agriculture.
- A certificate of conformity shall be issued concerning plant protection equipment which proves to conform to the requirements upon testing.
- Certificates of conformity issued in modified bodies of foreign states are recognised in Estonia.
- The costs of testing shall be borne by the owner of the equipment which is tested.
- Plant protection equipment which is in use, except spray guns and knapsack sprayers, shall undergo inspection once every three years.
- The Plant Production Inspectorate shall exercise supervision over compliance with the requirements provided for in the “Plant Protection Act” and legislation established on the basis thereof.
- The procedure for the inspection of plant protection equipment and the agencies which perform inspection are determined by a regulation of the Minister of Agriculture.
- The imposed procedure for the inspection of plant protection equipment was worked out on the basis of (Pr)EN 13790.
According to the “Plant Protection Act”, the Estonian Research Institute of Agriculture and legal persons, entered in a contract with the Minister of Agriculture are performing the inspection of plant protection equipment.

The costs of inspection shall be borne by the owner of the equipment.

Violation of the safety requirements for plant protection equipments, or the requirements for the manufacture, importation, marketing or inspection of such equipment is punishable by a fine of up to 100 fine units.

The same act, if committed by a legal person, is punishable by a fine of up to 15 000 Estonian kroons (ca. 960 EURO).

The author of this paper (one leader of this work) participated in training seminars for inspection of plant protection equipment in Finland and Denmark.

For training inspection personnel for Estonia four training seminars have been organised by the Estonian Research Institute of Agriculture.

Due to failing finances for procurement equipment for inspection only 5 private companies and the Estonian Research Institute of Agriculture are inspecting plant protection equipment at the present time.

Approximate age of plant protection equipment in Estonia:

- < 5 years 7 %
- 5…10 years 8 %
- 10…15 years 35 %
- > 15 years 50 %

Since 2000 about 5 % of the plant protection equipment in Estonia is inspected.

A lot of old trailed plant protection equipment from soviet times is substituted mostly with Hardi parts (old chassis and tank, all other parts are new).

Producers: more than 60 % from Hardi; others: Amazone, Rau, John Deere, Kasi, Junkkari, Kuhn, Gambetti Barre, Bury, EHO, Agroma…

Structure of field sprayers (previous 5 years):

- mounted 72,7 % incl. 6,5 % air-assisted
- trailed 26,0 % incl. 7,8 % air-assisted
- self-propelled 1,3 % incl. 0,6 % air-assisted
Inspection of sprayers in Hungary

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Hungarian Institute of Agricultural Engineering, H-2100 Gödöllő, Tessedik u. 4., Hungary

Summary
The Plant Protection Act issued in 2000 and its enacting clauses regulate the examinations of plant protection machines in Hungary. Field and air-assisted sprayers, lever-operated and motor-powered knapsack sprayers, seed dressers and machines, adapters for spreading grains with a tank volume of more than 5 dm³ may only be distributed from the 1st of January 2004 with a type approval according to the requirements of the standard EN 12761 and with the plaquette verifying the selling license. Sprayers with a tank volume of more than 100 dm³, used for contracting jobs will be subject to a regular inspection from the 1st January 2005 every two years according the requirements of the standard EN 13790. Authorized stations carry out these inspections and issue the plaquette verifying the permission of operation. The plant protection authority will control the selling licenses on the base of the type approval, the permissions for operating and the skills at operation.

1. Introduction
The plant protection based on chemicals is not only a series determined mainly quantity and quality of the yield, but also a dangerous activity against our environment. The result of the protection operations and their effect on the environment depends also from the utilized machines. The design and the technical status of the plant protection machines has great influence on the accuracy of the dispersing of chemicals, determines the losses what contaminating or damaging the environment. It exists in Hungary since 1968 a decree for fulfilling of plant protection operations with convenient machines in a way not to contaminate the environment and having an uniform distribution, but only the Plant Protection Act issued in 2000 and its enacting clauses regulated in detail the conditions of the supervision. The examinations are carried out in three steps:

- Type approval before distribution/selling.
- Regular inspection of sprayers already in use.
- Control on site during operation.

The inauguration will be made by progressive stages. The establishment and the carrying out of the supervisions are highly supported by the European standards accepted in the last years.

2. Materials and methods
2.1 Type approval of plant protection machines
Plant protection machines may have been distributed in Hungary from the 1st January 2004 only with a selling license based on type approval. Obliged to inspection are all machines with a tank volume of more than 5 dm³ in following categories:

- Field crop sprayers and vaporizers
- Air assisted sprayers and vaporizers for vineyards and orchards
- Portable not-motorized sprayers
- Portable motor-powered sprayers and atomizers
- Seed dressers
- Machines/adapters for spreading grains

The certification is made by the Hungarian Institute of Agricultural Engineering of the Ministry of Agriculture and Rural Development (FVM MGI – Gödöllő) according to the standard-series MSZ EN 12761 and the requirements of the above-mentioned decree.
According to this decree the machines listed above may only be permitted for selling after the 1st of January 2004 with the approval of the Institute. The manufacturer or dealer of the plant protection machine is requested before the distribution to declare that the machine-type in question meets the requirements and to ask for the selling license. This application should be submitted on a formula according to the decree, enclosing followings:

- User’s manual(s) in Hungarian language
- Protocol(s) to labour safety
- In the case of a family of machines the matrix determining the types
- Data sheet to identify each type (each line in the combined matrix is a separate type)

Further if staying at disposal:

- Hungarian or foreign quality certificates
- Other documents necessary for judgment of the machine(s).

If the submitted documents are unsatisfactory, the Institute requires a completion. At the certification process will be used the earlier examinations of the Institute and the result of the tests/certifications carried out by the members of ENTAM (European Network for Testing of Agricultural Machines) according to similar requirements (EN 12761).

The type approval should be carried out on the base of the submitted documents. If these are unsatisfactory, the judgment of the suitability can be carried out by a survey as well. If no results according to the above mentioned requirements are staying at disposal of the Institute, the examination will be made at the seat of the Institute in Gödöllő and here will be decided about the suitability. To this test the applicant should deliver one machine to the seat of the Institute and return after closing of the examination.

In the case of a machine-family only one member should be tested, all the other members of the family will be judged on the base of documents or by survey.

On the base of the submitted documents, of the survey or of the test the suitability of the machine will be judged according the requirements of the decree and the Institute issues or refuse the permission for selling.

The type approvals issued by the Institute are generally valid for 5 years. In the case of defects and deviations not influencing significantly the protection of environment will be issued a temporary selling license. After this period of validity the permission should be prolonged by a new declaration.

The Institute is entitled to make a new test within the validity period of the selling license, if a quality loss or a technical amendment gives rise to a suspicion. If the suspicion is right the selling license will be withdrawn by the Institute.

The selling license should be displayed on all distributed machines in form of a plaquette with the number and the validity of the permission.

The approved machines are registered by the Institute (in the List of Plant Protection Machines Approved for Selling) and published as well.

The judgment of the applications and the issuing of the approvals / selling licenses are already going on.

### 2.2 Regular inspection of sprayer

From the 1st of January 2005 the regular inspection of all sprayers and vaporizers with a tank volume of more than 100 dm³ used for services will be obligatory by law in every second year. The aim, the methodology and the requirements of the inspection of sprayers already in use are determined in the standard MSZ EN 13790.

Control stations having the authorization of the Institute FVM MGI will carry out the regular inspections. An authorized station should possess:
A leader having the qualification as technician and the medium state degree in plant protection, further an entrepreneur permission under consent of the Hungarian Chamber of Industry and Trade;

One skilled workman at least, suitable prepared for performing his task;

The prescribed measuring equipments and devices.

The devices and measuring equipments necessary for the inspection of sprayers are the followings:

**Inspection of field crop sprayers:**
- Spray tables for liquid distribution measurement at least with a length of 12 m, measuring depth 1.5 m and patternators with gutters of 10 cm;
- Flow meter for measuring of the capacity of pumps;
- Manometer tester, equipped with a high precision reference manometer 0-16 bar, quality class 1.0;
- Flow meter or measuring glass for controlling of the flow rate of the nozzles;
- Angle meter;
- Revolution counter 0-3000 min⁻¹;
- Measuring tape;
- Motor vehicle for transport of the measuring equipments.

**Inspection of air-assisted sprayers for vineyards and orchards**
- Flow meter for measuring of the capacity of pumps;
- Manometer tester, equipped with a high precision reference manometer of 0-60 bar, quality class 1.0;
- Flow meter or measuring glass for controlling of the flow rate of the nozzles;
- Angle meter;
- Revolution counter 0-3000 min⁻¹;
- Measuring tape;
- Motor vehicle for transport of the measuring equipments.

To the devices belongs in both cases a trough to collect the liquid running out at the measurement.

The mobile stations should be equipped in interest of an effective measurement and of the assuring of similar measuring results with uniform measuring devices. Following instruments should be obtained at first:
- Spray scanner (patternator), computer-controlled, telemetrically, with ultrasound level measuring for determination of the liquid distribution under the spray boom;
- Flow meter for measuring of the capacity of pumps;
- Electronic flow rate measurement device with ultrasound level measuring for nozzles.

The control stations will work prospectively according to a yearly plan. Every station will publish its field of action, site and date of inspections. The control stations present their plans of inspection to the Institute FVM MGI for checking up to 15th January in every year. At compiling a plan, the control stations have to strive for accomplish the inspection from 15 km distance of any operation site in the given year. Inspections can be carried out at the given habitation or region several times within a year. The plan has to be collected in a way that it can be kept independent of the number of applicants and other circumstances. The plan of inspections should be published after its confirmation.

Owner of the sprayer have to present oneself for inspection 30 days before the end of the inspection obligatory. Registering for inspection have to send to the address of a given control station, that will inform the applicant about the date of inspection by mail. The sprayer can be used up to the date of inspection according to its function.
The owner of the machine or his representative is obliged to appear in the appointed time with the clean machine, ready for working and with a tractor for its operation. The tank of the sprayer should be filled up to 25% of the nominal volume with clear water. The inspection will be carried out against payment. The owner of the machine or his representative has to present the receipt of payment of the inspection fee to the leader of the station before beginning of the inspection. The machines will be controlled on the base of the uniform methodology. The owner of the machine or his representative may be present at the inspection. The results of the inspection will be registered in a prescribed protocol.

If the result of the inspection is satisfactory, the station issues the licence verifying the operational permission of the sprayer. If the technical condition of the machine is – on the base of the results of the inspection – unsatisfactory, the permission cannot be issued. If the detected troubles or defects can be repaired in a short time (e.g. by exchange of the nozzles or of the manometer), the inspection should be repeated – if possible – at the given station in a new appointed time against payment of a new fee.

The plant protection authority will control the operating permission of the sprayers.

At the moment is the regular inspection obliged by law only for sprayer fulfilling service-works as contractor or member of a machinery ring. It is awaited that a part of not obliged machines will be voluntary inspected as well, so that the demand on inspection is difficult to estimate. It is expected that 15-20 mobile stations would be enough at the beginning for carrying out of the inspections.

The decree prescribes the inspection for the time after the 1st of January 2005. For lack of time the applications for establishment of a control station should be urgently collected. The staff/employees of the stations should be complete training courses at the end of 2004 to become acquainted with the system, the requirements and the methodology of the inspection.

2.3 Control of plant protection activities on site during operation

The plant protection machine should fulfill the prescribed requirements at each operation; otherwise the plant protection authority stops the operation until repairing of the defect.

3. Conclusions

It is expected that the initiated control system of plant protection machines in Hungary contribute to the increasing of the security of the operator, to the reducing the damage of the environment and to the improvement of the effectiveness of the treatment with chemicals. Insufficient in this system is that the regular inspection is obliged only for machines carrying out service-jobs as contractor. It seems to be necessary to extend the inspection to all operating sprayers under using the first gained experiences.
Inspection of plant protection equipment in the Czech Republic

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Summary

In the present economical and environmental situation, it is necessary to assure the quality of pesticides application as far as possible. Most countries have adopted strict laws concerning the placing onto the market of pesticides and concerning their quality application. The inspection of plant protection equipment (PPE) already in use, is one of the steps to improve crop protection and reduce a potential danger of environmental contamination.

1. Introduction

In the Czech Republic the inspection of PPE system was established as obligatory in 1997. The inspection of PPE covers field crop sprayers, air-assisted sprayers for bush and tree crops, seed treaters and aerial application equipment. State Phytosanitary Administration, Application Technique Dept., is responsible for the approval procedure of testing stations and for supervising over obligatory inspection, especially the good performance of testing stations.

Application Technique Dept. is responsible for the registration of new PPE brands.

2. Materials and methods

2.1 Standards and requirements

The requirements and methods for inspection of PPE are set in Act No. 147/1996 on phytosanitary care. Procedures for carrying out inspections, requirements for testing facilities and their accuracy were based on ISO 5682-2 and the German PPE inspection model. At present, requirements for inspection are stated according to EN 13790 – 1. New act with these requirements will come into force in May 2004.

3. Conclusions

The inspection of PPE already in use is a functional system in the Czech Republic. 55 testing stations were approved in the Czech Republic. 50 % of PPE already in use were inspected during three two-year periods in the Czech Republic.

Acknowledgements

Special thanks to Dr.-Ing. H. Ganzelmeier from BBA for support.

References

Voluntary testing of sprayers in Sweden, experiences and future

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The current voluntary system of sprayer testing is at the moment under investigation. It was introduced in 1988, supported with subsidies from the government, research at the university and good publicity in farmer’s magazines.

So far orchard sprayers have been exempted due to a lack of test regulations (see paper elsewhere, Sven-Axel Svensson).

The estimated number of trailed, self propelled and mounted sprayers that are in use in Sweden range between 12,000 and 22,000, with the latest estimate of 19,000. This also includes about 250 orchard sprayers.

During the first 11 years of voluntary, subsidised testing approximately 19,000 tests were performed. That makes a test frequency of about 9% per year. Some of the machines were also tested more than once during the period. In a survey in 1998 it was concluded that 34% of the machines were tested every one or two years. These figures can be questioned since they are not the same but we conclude that the test frequency is low.

The subsidies during this period included a fixed sum per test (approximately 100 €) and also for the purchase of test equipment (50% of the cost up to 5000 €). We now have a total of 150 testers educated by the Board of Agriculture. At the moment the absolute majority of these use “Lurmark” patternators for testing spray distribution.

After this first period the 100 € subsidy for testing was included in a more general program aimed at reducing the negative side effects of pesticide use and intensive cereal production (REKO) but this is now being dismantled. Since 1998 – 1999 we have seen the market introducing contracts demanding use of tested sprayers. Examples are sugar beet production (Danisco), Swedish Seal (Svenskt Sigill) which mainly certifies cereals and IP production of vegetables and now also fruit (this year).

How have these voluntary systems influenced the test frequency? The only estimation of how many tests are performed at the moment is from the numbers of test protocols and stickers that are sent out by us (the Board of Agriculture) that have the central responsibility for the test system. During 2002 a total of 3400 stickers where distributed to testers around the country. These were mainly sent to southern Sweden (Scania) where we have the sugar production (3800 contracted beet growers) and the majority of our sprayers.

Why is the system under investigation?

• It is questioned whether a governmental institution can prescribe in matters that are basically voluntary.
• The REKO subsidy is being withdrawn.
• We have not accomplished what we set out to do, that is to reach a very high test frequency on a voluntary basis.

The ongoing investigation is to be finalised during September, 2004 and then it is up to the ministry of agriculture to decide how Sweden will continue. The main route, at the moment, is to make it legal to spray only when using tested sprayers, based on environmental legislation.

The main difference between the Swedish testing guidelines now and the CEN standard is the demands on test equipment for testing spray distribution. We will have to consider if, how and when to introduce test equipment that meet the demands in EN 13790. Other considerations are how to handle sprayers located in Sweden’s more sparsely populated areas where transport of either sprayers or test equipment will be expensive.
Activity and organisation of sprayer inspection service in the Basilicata region, Italy
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Summary
Currently, in Italy the testing of sprayers for crops is neither compulsory nor submitted to prescribed procedures stated by law.

Even in the Basilicata region, the testing of sprayers is only voluntary. Since 2003 a regional Sprayer Inspection Service (Se.T.I.) is operating and it is managed by the A.L.S.I.A. (the regional Agency for Development and Innovation in Agriculture). The aim of Se.T.I. is to improve the rational distribution of pesticides in order to reduce environmental impact and operator hazards.

The team of the Se.T.I. works by using a ‘moving inspection and calibration set’, which is assembled in a van that moves, easily and quickly, round the Basilicata area.

Inspection and calibration of sprayers are carried out by the application of Italian guidelines (Agricoltura Qualità – Mis. 4).

At the moment 287 farmers have required sprayer testing. Most of them (about 70 %) are members of co-operatives and trade associations which require as an essential requisite to stipulate contracts a certification of the suitability of sprayers.

A large part of the requested inspections, therefore, has not been made by the farmers in order to improve the efficiency of pesticides, but only in order to show a certification.

Among the failures often detected, some are easily mendable by correct maintenance but, if not fixed, can adversely affect the efficiency of pesticides’ distribution. In order to effectively improve the distribution of pesticides in future, the following requirements will be necessary:

• To emphasise training and instruction of farmers regarding correct maintenance and setting of their sprayers;
• To make farmers responsible by having them pay a contribution to the testing expenses;
• To improve the organisation of the service and introduce coding of its procedures by regional regulation;
• To get in touch and start co-operating with public research institutions.

1. Introduction
Currently, in Italy the testing of sprayers for crops is neither compulsory nor submitted to prescribed procedures stated by law; however the 20 Italian administrative regional districts (which are greatly independent in respect to agricultural regulations) have acknowledged the EU suggested prescriptions about sprayers quite heterogeneously.

The requirement for a rational distribution of pesticides is more and more felt to be of importance in the EU, in Italy and even in the Basilicata region, due to the efforts of Governmental bodies devoted to promoting low-environmental-impact production techniques.

Also the sensibility of the farmers and of their trade organisations to that problem is rising, especially because the ‘Organised Big Distribution’ more frequently requires a certification of the suitability of the sprayer as a pre-requisite for drawing up a contract.

The Basilicata region has not yet issued any act for regulating the inspection of sprayers although it is interested in prescribing periodical inspections, at least for those farms which receive grant-in-aid for the application of low-environmental-impact techniques. For that reason the Basilicata region has introduced the (Se.T.I.) in 2003, entrusting its running to the A.L.S.I.A. (the regional Agency for Development and Innovation in Agriculture).
The aim of Se.T.I. is to improve the rational distribution of pesticides in order to reduce environmental impact and operator hazards. Currently, the Se.T.I. is being set up, and its main aim is spreading knowledge of the related techniques among the farmers. For that reason the service is fully financed by the Basilicata region and thus offered free of charge.

The organisation of the Se.T.I., its activities and experiences until now are presented and discussed in this work.

2. How sprayer inspection service works

The team of the Se.T.I. consists of: a supervisor who plans the activity, a technician and a mechanic specialised in using a ‘movable inspection and calibration set’ - made by Extel (a firm in Verona, Italy) - which is assembled in a van that moves, easily and quickly, round the Basilicata area.

The Se.T.I. working procedure has been created to reduce difficulties and risks originating from transporting tractors and sprayers by road.

Inspection and calibration of sprayers are carried out according to Italian guidelines (Agricoltura Qualità – Mis. 4).

Testing requests are collected by e-mail, phone or fax, and testing itself is scheduled whenever a minimum of 5-10 requests has been collected from small local areas.

The Se.T.I. usually gets in touch with town councils, farmers' associations, co-operatives etc, to organise the stay of the ‘movable testing equipment set’ for a short period. Before the inspection of sprayers ALSIA technicians give instructions to the applicant farmers for them to prepare the equipment for inspection, table 1.

<table>
<thead>
<tr>
<th>Table 1: Fundamental checklist to prepare the sprayer for inspection and calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Here are 10 simple rules in order to appear at the inspection and calibration without problems.</td>
</tr>
<tr>
<td>1) Anti drip device: if the anti drip device can be updated it should be mounted.</td>
</tr>
<tr>
<td>2) Pump: check the oil level and possible leaks.</td>
</tr>
<tr>
<td>3) Pneumatic pressure pulsation damper: if mounted, check the pressure (6-8 atm.). If there is water in it its membrane must be changed.</td>
</tr>
<tr>
<td>4) Pressure-gauge: it must be readable; no leaking of glycerine. If the sprayer is not in operation the needle must point to zero.</td>
</tr>
<tr>
<td>5) Filtering: make sure that all filters are in place and that they are perfectly clean.</td>
</tr>
<tr>
<td>6) Tank and pipe system: check that tank, pipes and pipe connections do not have any leaks when the sprayer is in operation.</td>
</tr>
<tr>
<td>7) Pressure regulator: make sure it is working alright.</td>
</tr>
<tr>
<td>8) Fan and air distribution: make sure it is working alright.</td>
</tr>
<tr>
<td>9) Pump’s characteristics: The aluminium plate recording the machinery’s characteristics must be available.</td>
</tr>
<tr>
<td>10) Tractor: make sure the engine speed indicator works efficiently.</td>
</tr>
</tbody>
</table>

In order to test the machine, it must have been serviced correctly, it must be very clean (to respect the technicians’ health) and clean water must be in the tank.

The machinery’s owner must make sure that the sprayer and the tractor are furnished with safety devices.

Results of sprayer testing are recorded in a ‘certificate’ issued to the owner.

Moreover, data collected during the inspection and calibration is stored in a regional database, useful for monitoring and planning further activities, fig. 1.
3. 'In the field’ for 18 months: some results

More than 3,000 farms in the Basilicata region are equipped with sprayers. These farms have got more orchard sprayers than field sprayers. In irrigated areas of the Basilicata region all farmers usually work with the same sprayer on different tree crops with very different training systems (such as open vase, delayed vase, transverse epsilon, pergola, palmette, globe, etc.).

At the moment 287 farms which make use of sprayers have required the Se.T.I. testing. Most of these farms (about 70 %) are members of co-operatives and trade associations.

Some information and results concerning the first 243 inspections of sprayers carried out until now are reported.

Table 2 shows the costs and the time-length of activities; table 3 shows the types of sprayers; table 4 shows the age of the inspected machines. The main problems and failures found out during inspections are reported in table 5.

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Table 2: Costs and length of time for sprayer inspection and calibration.

<table>
<thead>
<tr>
<th>Information events</th>
<th>n° 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspected sprayers</td>
<td>n° 243</td>
</tr>
<tr>
<td>Average costs/sprayer</td>
<td>€ 130</td>
</tr>
<tr>
<td>Average sprayers/day</td>
<td>n° 3,5</td>
</tr>
<tr>
<td>Average time/sprayer</td>
<td>hours 2.00</td>
</tr>
</tbody>
</table>

Table 3: Types of inspected sprayers (percentage of 243).

<table>
<thead>
<tr>
<th>Type of sprayer</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchard sprayers</td>
<td>64 %</td>
</tr>
<tr>
<td>Canon head air blast sprayers</td>
<td>22 %</td>
</tr>
<tr>
<td>Field sprayers</td>
<td>14 %</td>
</tr>
</tbody>
</table>

Table 4: Age of inspected sprayers (percentage of 243).

<table>
<thead>
<tr>
<th>Age</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 0 to 5 years old</td>
<td>19 %</td>
</tr>
<tr>
<td>From 6 to 10 years old</td>
<td>45 %</td>
</tr>
<tr>
<td>From 11 to 15 years old</td>
<td>19 %</td>
</tr>
<tr>
<td>More than 15 years old</td>
<td>17 %</td>
</tr>
</tbody>
</table>
Most of the sprayers used in the Basilicata region are orchard sprayers which are fairly new (1/3rd is from 1 to 5 years old) and thus are equipped with a quite satisfactory technology. As for the field sprayers used for grass or horticultural crops the situation is rather different since they are often more than 20 years old.

Finally, a survey carried out among farmers has shown that operational pressure and sprayed volumes applied are often very different, for the same field conditions.

4. Discussion

Continuation of this work yielded interesting data that give useful hints for improving efficiency and spreading of the service.

A large part of the requests for the Se.T.I. has been made by farms which are member of producers’ associations requiring a testing certification (e.g. eurepgap). Farmers thus do not make the inspection request in order to improve the efficiency of pesticides but only in order to show a certification.

Actually, the testing, even if free of charge, is often regarded by the farmer to be useless and they distrust the test, although the testing service staff often points out insufficient maintenance and incorrect usage of the sprayer (tab. 5)

Table 5: The main failures and problems found with the 243 sprayers inspected so far.

<table>
<thead>
<tr>
<th>Failures and problems</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Take Off (PTO) used at too low rotational speed</td>
<td>38.4%</td>
</tr>
<tr>
<td>Wrong speed of the tractor</td>
<td>28.3%</td>
</tr>
<tr>
<td>Inefficient pump flow or inadequate pump</td>
<td>2.4%</td>
</tr>
<tr>
<td>Broken or inefficient pressure gauge</td>
<td>68.7%</td>
</tr>
<tr>
<td>Broken, worn or dirty nozzles</td>
<td>21.7%</td>
</tr>
<tr>
<td>Broken or inefficient pneumatic pressure pulsation damper</td>
<td>8.4%</td>
</tr>
<tr>
<td>Inefficient or worn pressure regulator</td>
<td>4.8%</td>
</tr>
<tr>
<td>Broken engine speed indicator</td>
<td>3.6%</td>
</tr>
<tr>
<td>Missing PTO guard</td>
<td>30.1%</td>
</tr>
</tbody>
</table>

To improve the situation a good feeling should be created between technicians and farmers during the inspection procedure, and that the farmers can directly experience the detected failures and the improvements introduced to their own machinery.

Among the failures often detected some are easily mendable by correct maintenance but, if not fixed, can lower the efficiency of pesticides’ distribution. More than 2/3rd of the inspected equipment had a broken or insufficiently working pressure gauge; about 20% had worn nozzles, and about 8% had a broken pneumatic pressure pulsation damper. Lastly, it has to be noted that a great percentage of the contacted farmers used PTO with too low rotational speed.

In future, in order to effectively improve the distribution of pesticides, it will be necessary:

- to improve the training and instructing of the farmers about the right maintenance and setting of their sprayers;
- to make farmers responsible by having them pay a contribution to the testing expenses;
- to improve the organisation of the service and the introducing coding of its procedures by regional regulation;
- to get in touch with and start up co-operation with public research institutions.

References

Inspection of sprayers in Greece

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Greece has fully applied the Machinery Directive that includes interchangeable equipment assembled with a tractor since 1993.

As it is well known, sprayers are not referred to in Annex IV of the above Directive (98/37/EC) so the manufacturer or his representative is obliged to sign an EC Declaration of Conformity after having available for any inspection purposes the technical construction file of the machinery and the internal measures that ensure conformity. According to this procedure tests carried out by a competent body or laboratory are optional. Therefore manufacturers are obliged to affix to the machinery distinctly and visible the CE marking and to include if they so desire tests in the machinery technical construction file.

The Ministry of Agriculture has realised the importance of inspections and tries to establish them as compulsory tests according to European and international standards either for new sprayers or for sprayers in use. However, some Greek manufactures argue against this policy claiming that it is breaking the EC law, according to which the Member States shall not prohibit, restrict or impede the placing on the market and putting into service in their territory of machinery which complies with Directive 98/37/EC. Therefore tests of new sprayers are still voluntary and they are carried out only after the manufacturer’s request, though tests of sprayers in use need to be discussed further and gain acceptance.

Recently farmers have supported the opinion that primarily all old sprayers should be withdrawn and replaced under the Ministry’s supervision and with its subsidy, and as a consequence, inspection of sprayers in use can be applied partially. This proposal carries the confidence of productive and commercial unions and is going to be submitted to the authorities soon.

In Greece there are almost fifty industries of air assisted and low crop sprayers settled in the North of the country which employ about 400 workers. Annually about 2000 of the above sprayers are produced that are placed mostly on the domestic market. The maximum capacity of the plant protection machines is approximately 2000 l for air assisted and 1000 l for field crop sprayers.

Tests of sprayers are carried out mainly by I.A.M.C. (accredited by EN ISO/IEC 17025 and certified by ISO 9001/2000) according to several clauses of EN 12761, EN 907 and ISO 13440 standards.

Test results concerning essential health and safety requirements relating to the design and construction of sprayers (EN 907) as well as inspection of the manufacturer’s technical construction file and instruction handbook illustrated that the self conformity assessment procedure is insufficient.

Test results indicated also that a number of machines do not fulfill all the requirements of the relative standards (EN 907, EN 12761) mainly due to lack of information and misunderstanding of the technical requirements. The institute puts a lot of efforts into covering this gap and into affronting the cases that even imported components of the machines do not meet all the requirements of the standard EN 12761.

I.A.M.C’s facilities are expected to be upgraded in the next future in order to cover all ENTAM methodology.
Overview of the sprayer inspection in Belgium

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Summary

The inspection of sprayers is compulsory in Belgium since 1995. The motivation for introducing the compulsory inspection after 5-7 years of inspection on a voluntary basis were the bad technical results observed during the voluntary stage, the excessive supplementary costs for the farmer, 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.

Official teams from regional authorities (Agricultural Research Centres) carry out the compulsory inspections. Responsible for the management of these inspections is the Federal Ministry of Public Health, Safety of the Food Chain and the Environment. In total there are six inspection teams for the whole of Belgium. They inspect approximately 24 500 sprayers every three years. 10 to 14 sprayers are inspected each day by one team.

During the voluntary stage only 24 % of the inspected sprayers were in perfect functioning condition, about 50 % had one or two significant defects and about 25 % of tested sprayers were to be replaced by new equipment. Since the implementation of the compulsory inspection the results are totally inverse. At the moment less than 15 % of the sprayers are rejected. The reasons of this improvement are mainly a better preparation of the sprayer before the inspection, successful sensitisation of the farmers, the long time of vulgarisation before and during the voluntary stage, and the psychological effect of a rejection. The fourth inspection cycle will start in September 2004.

1. Introduction

The Federal Ministry of Agriculture requested in its Policy Note of June 1993 to implement a compulsory inspection for crop sprayers and atomisers (orchards sprayers) already in use in Belgium (Huyghebaert et al, 1996). This implementation was intended as a part of the Belgian agricultural restructuring planned in the framework of the CAP reform and the GATT negotiations. Moreover, different studies conducted for several years pointed out the poor functioning state of the sprayers in use. Consequently, a federal working group was set up in October 1993, being commissioned to study the practical organisation of a mandatory sprayer inspection. This working group was composed of representatives of all stakeholders : federal and regional governments, farmer’s associations/unions, manufacturers, universities and research centres. After 2 years, a draft bill was proposed and the Belgian Ministry of Agriculture implemented on 04 September 1995 a compulsory inspection of crop sprayers already in use in Belgium. This new regulation met the National and European will to improve the condition of crops sprayers, the image of agriculture in the eyes of consumers of agricultural products, and environmental protection. (Huyghebaert and Mostade, 2002).

2. Description

2.1 Legal basis

The compulsory sprayer inspection in Belgium is based on the Ministerial Decree (09 June 1995) published in the Belgian Official Journal (12 August 1995). This decree constituted the legal basis of the sprayer inspection. This basic document has been updated from time to time and the current version of 23 August 2001 (published 31 August 2001) is in force.

This document of 39 pages describes precisely the administrative organisation (responsibility organisation chart), the inspection protocol, the tolerances and all the official documents (sticker, report, declarations…) of the sprayer inspection.
2.2 Who, what and when?

The sprayer inspection concerns all machines which apply pesticides registered for agricultural use in liquid form, working on Belgian territory. Manual, gas pressurised and knapsack sprayers are excluded.

The sprayers shall be presented for inspection every 3 years. If the machine passes the inspection it gets a sticker and a positive report and can be used for the following 3 years. When it fails the inspection, the sprayer must be repaired and presented again for inspection after 3 months at the latest.

The inspection fees rate from 70 € to 142 € and depend on the boom length. For orchard sprayers the fees are fixed at 70 €. The second inspection price rates from 12,50 € to 62,50 €, depending on the type of defect.

2.3 Inspection protocol

The method has especially been developed to meet the specific constraints and objectives of the inspection of sprayers in Belgium. Based on the analytical principle, the method consists of measuring separately and independently the performances of the different parts of the sprayer so as to determine the defect and to establish a precise diagnosis. The key words for this particular method are : objectivity, reliability, precision, education and well adapted to the field (Huyghebaert et al. 1999-2).

The state of maintenance and the safety parts are checked visually on the sprayer. The good state of the protections and of the boom, the positioning of the nozzles, the cleanness of the filters and the legibility of the pressure gauge are elements that are essential to check in order to ensure a spraying performance which is absolutely safe.

The pressure gauge and the pressure distribution of the whole sprayer are checked in order to guarantee a homogeneous feeding of all spraying nozzles, fig. 1. The output of each nozzle is measured independently of the sprayer on a specific test rig, fig. 2. This reliable and precise method allows to measure the performance of the nozzles without being disturbed by a defect of another part of the sprayer.

![Figure 1: Reference pressure gauge on the boom.](image-url)
All tests and measurements are encoded and stored on a data processor. The analysis is automatic and does not require human intervention. The report is printed on site. This computer management adapted to the field combines reliability and precision and reinforces the openness of the inspection.

2.4 The organisation

The organisation of the sprayer inspection in Belgium lies within the responsibility of the authorities. The inspection services (Agricultural Research Centres of Gembloux and Merelbeke) take care of the daily management under the aegis of a central secretariat (AFSCA Federal Agency for the Security of the Food Chain) which liaises with the inspectorate service (repressive element of the organisation). Annual reports are submitted for the approval of a Steering Committee. The latter is made up of the partners (public, private and associative) concerned with the inspection of sprayers. Its function is to guarantee the objectivity of the inspection.

The users of sprayers are contacted individually. They are invited to go to a place close to their house in order to submit their sprayer to an inspection. The convocation clearly stipulates the methods of inspection (preparation, causes of refusal, costs etc.)

For the whole of Belgium more than 416 inspection places have been identified and are regularly visited. This division of the country into small testing zones cuts the travelling distance for every user down to less than 20 km.

The mobile inspection teams daily visit the different places following a schedule, fig. 3. Two specialised technicians carry out the complete test for more than 12 devices in one day. This efficiency limits the costs for the user.
By the end of the test the operator writes down a full report including, should this happen, precise information about the repairs to be carried out. This didactic inspection allows the user to understand better the functioning of his equipment. In case of acceptance, a sticker attests the conformity of the sprayer.

3. Results and conclusions

In Belgium there are 55 000 farms and the total cultivated surface amounts to more than 1 392 000 hectares (De Baets, 2004). About 24 500 sprayers are in use (21 000 boom sprayers and 3 500 orchard sprayers). Six teams of 2 technicians, 1.5 engineers and 2 secretaries are necessary to organise and realise the inspection of all sprayers in use in Belgium within 3 years.

The inspection is financially self-supporting. The annual costs of about 690 000 Euros are entirely covered by inspection fees. The average costs arising for the user amount to about 92 Euros.

Less than 15 % of the inspected sprayers are rejected after initial testing. These results differ from those obtained within the framework of voluntary inspections (from 1989 to 1995). This difference can be mainly explained by the fact that, at present, users repair their sprayer beforehand, taking the notification into account (Huyghebaert and al, 1999-1).

A defect leads to a refusal only when its origin is ascribable to the user, when it disturbs the spraying in a significant way and when it has been determined in an indisputable and objective way. The repair must be carried out within 4 months when a second inspection of the sprayer takes place.

A secondary deficiency does in no case lead to the refusal of the sprayer. However, it is mentioned in the report of the diagnosis and must in any case eliminated before the following inspection (3 years later).

Finally it can be concluded that the Belgian Minister succeeds in establishing a realistic, non-arbitrary and educational inspection which is at the same time reliable and precise. The objectivity of the inspection is guaranteed by a public management and the inspection is financially self-supporting (Sawa et al, 2002).

A balanced and realistic project has been finalised by taking into account the constraints of the different partners. In Belgium, a compulsory inspection of sprayers using pesticides for agriculture is successfully on the way since 1995. Technical improvements of the sprayers as well as a positive evolution of people’s mentality has been observed.

References


Results Session 1 – Actual inspections in the Member States and their comparison with EN 13790

1. Current situation in the Member States (MS) and candidate countries (CC)

1. It is recognised that a safe and accurate application of pesticides is essential for an efficient agricultural production as well as for operator safety, environmental protection and food safety. Therefore, a proper application technique plays an important role. MS do agree that an inspection of sprayers in use is appropriate to obtain a high working quality of sprayers during their lifetime.

2. Almost all of MS and CC make efforts to implement a sprayer inspection (mandatory or voluntary)

Implementation of inspection, Figures 1 and 2:

Experimental state
- field sprayers: FI, ES, DK, AT, HR
- air assisted sprayers: AT, HR

Voluntary
- field sprayers: SE, UK
- air assisted sprayers: UK

Mandatory (or will be mandatory)
- field sprayers: BE, DE, HU, IT, LT, NO
- air assisted sprayers: BE, DE, ES, HU, IT, LT, NO, NL, PL, SE, SI

Figure 1: Implementation of inspection of field sprayers in Europe.
3. EN 13790 was established to define requirements for sprayers in use.
4. The European thematic strategy was published, discussing several options for sprayer inspection.

2. Objectives to improve the current situation
1. To establish a uniform level of sprayer inspections throughout the European Union by application of EN 13790.
   - standard procedure for training the personnel involved in the inspection
   - standardise the period an inspection certificate is valid
   - standardise the type of supervision of the inspection centre.
2. To establish European guidelines also concerning:
   - type of adjustment of the sprayers
   - how to use the sprayer in a proper way
   - others.

3. Need for further action – short-/long-term
   - EN 13790 inclusion into the national regulation in all MS and CC.
   - The inspection of application equipment in use to establish in all MS and CC.
   - To harmonise different national (MS & CC) legislations on sprayer inspection by complying progressively with EN 13 790.
   - To include the sprayer inspection into the production specifications (Eurepgap, labels, traders specifications…).
   - To develop a European standard also for the inspection of other types of sprayers (green house …).
   - To improve sprayer adjustment as part of inspection.
   - Others.
Session 2 - Administrative regulations required for establishing an inspection

The Belgian way of organising a compulsory inspection of sprayers

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Summary

The mandatory inspection of sprayers in Belgium differs in many ways from the inspections in other European countries. The most important difference is that until now Belgium is the only country in Europe where the inspection of sprayers is organised and carried out by the government itself. The arguments for this particular approach were expressed by the study group of experts who prepared the introduction of the inspection in the mid-nineties: 1) since objectivity and uniformity of the inspection are essential elements, the government decided that a private organisation of the inspection would be inappropriate; 2) the strategy of establishing mobile test teams with official inspectors has the advantage that the teams are specialised and that their equipment is continuously in use. The lower investment for replacing test equipment and the fact that the majority of the costs (over 80 %) are personnel costs are two other important advantages; 3) it is easier to implement an adequate quality policy on a centralised, well-structured service to ensure a good quality (accuracy, repeatability, traceability) of the inspections. This special approach has also other advantages in practice. It allows the secretariat to keep the central database, from which the inspections are planned, as good as possible up to date. As a result of the centralised organisation, it is also possible to perform a rapid and complete processing of the administrative and technical results of the inspections. Finally, the uniformity in implementing the inspection procedures and the inspection tariffs are two important advantages for the farmers that are the result of this way of organising the inspection.

1. Introduction

Since the beginning of the nineties, economic and environmental thinking in agriculture has focussed its attention on plant protection, and more specifically on the chemicals applied on the crops. Excessive applications of these plant protection products are not only uneconomical but have adverse consequences for the environment and for the image of agriculture. They can lead to intolerable residues in plants, environmental pollution and in the end to a resistance of pests and weeds to chemical agents.

Excessive applications can be attributed to the farmer or the spraying equipment. However, if the farmer follows the recommended dose stated on the package of the chemicals or in the accompanying leaflet, the excess can only be due to an imprecise distribution of the chemicals. Farmers generally don’t spray the same swath twice; hence the only possible cause left for uneven spray patterns is the sprayer itself. Maladjusted or badly maintained sprayers can spray up to 400 % of the desired dose while elsewhere on the field this may drop to as low as 20 %. In other European countries where sprayers are subjected to a voluntary or mandatory inspection, similar conclusions were reached.

The condition of the sprayer is closely linked with its maintenance. Unfortunately, not all farmers and technicians involved in servicing sprayers have the necessary technical expertise and experience. Even technical advisers may lack the know-how to adjust a sprayer correctly. The large variety of makes of spraying equipment, but often also the lack of proper service manuals for the marketed sprayers are to blame for this poor technical knowledge.

West European countries reacted differently to this situation. In Belgium three main actions were taken in the last decade. In a first stage, courses in spraying techniques and sprayer maintenance and adjustment were organised regionally. As only about 5 % of the farmers participated in such courses, other actions were needed. The ministry set up a working group comprising researchers, technicians,
manufacturers and farmers to develop a compulsory inspection of sprayers and standards for the certification of new spraying equipment. In this way, the government aimed at improving the condition of crop sprayers as well as the image of agriculture amongst consumers of agricultural products, and at reducing adverse effects of improper spraying. The mandatory inspection of sprayers is described in detail in the Ministerial Decrees of 9 June 1995, 31 August 1998 and 23 August 2001, which state that all sprayers used in Belgium have to be tested every three years. A new inspection cycle will start on 1 January 2005. Belgian standards for certification of new spraying machinery were established but their application must be in agreement with European legislation that is still awaited. The criteria in these standards are similar to those in the standard EN12761, part 1, 2 and 3 published at the beginning of 2001.

2. The mandatory testing of sprayers used in Belgium

2.1 Official structure of the inspection

Until now, Belgium is the only country in Europe where the inspection of sprayers is organised and carried out by the government itself. The arguments for this particular approach were expressed by the study group of experts that prepared the introduction of the inspection in the mid-nineties: 1) since objectivity and uniformity of the inspection are essential elements, the government decided that a private organisation of the inspection would be inappropriate; 2) the strategy of establishing mobile test teams with official inspectors has the advantage that the teams are specialised and that their equipment is continuously in use. The lower investment for replacing test equipment and the fact that the majority of the costs (over 80 %) are personnel costs are two other important advantages; 3) it is easier to implement an adequate quality policy on a centralised, well-structured service to ensure a good quality (accuracy, repeatability, traceability) of the inspections.

Although Belgium is a federal country and among many other subjects the agricultural policy is now a regional competence, regulations concerning the inspection of sprayers remain a federal competence because the use of sprayers for the application of pesticides is clearly regarded as an element of food production. The Federal Agency for the Safety of the Food Chain is competent for all issues influencing food quality. The Agency has the final responsibility for the mandatory inspection of sprayers in use in Belgium. Its main responsibilities and tasks are: 1) periodic (every three years) updating and publication of the legislation dealing with the mandatory inspection of sprayers in use in Belgium. Its main responsibilities and tasks are: 1) periodic (every three years) updating and publication of the legislation dealing with the mandatory inspection of sprayers in use in Belgium (current Ministerial Decree of 21/08/2001), 2) to chair the Federal Steering Committee that gathers every six months to discuss the financial and technical inspection results, 3) dealing with possible complaints of farmers who do not agree with the inspection results, 4) production and delivery of convocations, 5) processing of the regional administrative and technical results of the inspections. Representatives of the regional authorities, farmers associations, contractors and the regional inspection centres are represented in the Steering Committee. The actual organisation and execution of the inspections is delegated to two inspection services, one in each region. These regional services are housed in local research centres. They comprise a central secretariat and several test teams (4 in Flanders, 2 in Wallonia) that carry out the inspections.

For economical reasons and considering the limited numbers of sprayers and their poor mobility the authorities in Belgium opted for a system of mobile test teams each consisting of two official inspectors. Each test team carries out the inspection in a different region.

The main tasks of both regional secretariats are to organise and plan the inspections by the mobile test teams, to send out the convocations to the farmers, to register and archive the inspection results, to keep the database of farmers subjected to the mandatory inspection up to date, to follow up the technical and financial results of the inspections and to report these every half year to the federal secretariat (Federal Agency for the Safety of the Food Chain), and supervision of the different test teams. In order to keep the database of farmers up to date any sale of sprayers, new or second-hand, needs to be reported to the regional secretariats within 30 days after the sale. There is also a mandatory reporting if a sprayer is put out of use.
2.2 Organisation of the inspection

In Belgium, all spraying equipment used for the distribution of chemicals for plant protection has to be inspected, whereas in some other countries, until recently, only field sprayers (with a spray boom) required a compulsory inspection. This inspection applies to almost all sprayers, including those used for orchards and vineyards, fixed spraying installations in greenhouses, row sprayers, and equipment for golf courses and recreation areas, parks and streets. Lever-operated knapsack sprayers and portable compression sprayers, however, are excluded from this compulsory test. In this way, the legislation applies to all owners of spraying equipment and none of them are discriminated or privileged.

In order to inspect each sprayer in time, owners of spraying equipment are officially convoked to present their spraying machine at one of the test sites at a given date and time. The convocation is sent to the farmer at least three weeks in advance. In this way, the farmer can prepare his sprayer for the forthcoming official inspection. The convocation contains vital information for the farmer: location of the inspection and identification of the sprayer, the conditions of admittance, the 12 possible reasons that may lead to a rejection of the sprayer, the inspection tariffs and the stipulations for requesting a postponement of the inspection. Since the organising secretariat wants to keep the travelling distance for the farmers to a minimum, the tests are organised geographically and according to a predetermined time schedule. For the whole of Belgium, more than 416 inspection locations have been identified and are regularly visited. The test periods for each region are arranged according to the number, type and size of sprayers in that region. To minimise time loss for the farmers and to optimise the working hours of the inspection teams, farmers are convoked on a specific day and time. The time schedule requires some flexibility. This does not exclude the fact that a number of basic rules must be set out in advance and agreed upon (conditions of admittance).

2.3 The inspection methods

In Belgium, all parts influencing the distribution of crop protection agents are checked for proper operation, but not the distribution itself. By checking the sprayer parts another important objective of the compulsory test is fulfilled, namely the need for detailed information on present defects. The test is actually based on three main principles: a) if the manometer displays the correct pressure, the sprayer can be easily and precisely adjusted; b) if the pressure is uniform across the spray boom or in other words, at each nozzle holder, an equal volume will be spread by each nozzle; and c) if the nozzles are in a good condition, are not worn or filthy, a correct and uniform spray distribution should be obtained.

The tests applied in the compulsory inspection of sprayers in Belgium can be classified according to four themes viz. safety, clear and suitable measuring instruments, spray instrumentation and hydraulic equilibrium.

2.4 Reporting the results

All test results are noted on an inspection chart (raw data). Upon completion of all the tests, the inspection chart is used to produce the inspection certificate. This is done on the spot with specialised software. The certificate shows the detected defects in 3 categories of severity: 1) defects requiring immediate repair - sprayer rejected, 2) defects that need repair within 3 years - sprayer is approved, 3) minor remarks for an improved use of the sprayer. Besides identifying the defect, also an objective advice on how to solve the problem is given on the certificate. For the evaluation of parts that necessitate a measurement (e.g. flow rate of the nozzles), the results of these measurements are also stated on the certificate. The inspection certificate is always printed in twofold: one copy for the farmer and one for the archive of the inspection service.

In case the sprayer is rejected, only the certificate is handed to the farmer. It states that the owner has a period of four months to repair the defect and to present the sprayer for a second inspection. It is up to the farmer how and by whom the defects are repaired. When only defects of class 2 and 3 are found the inspection certificate mentions the validity period of the approval. Additionally, a sticker showing the validity period is attached onto the sprayer. These stickers have a unique number. Sticker and inspection certificate refer to the sprayer and not to the owner. Each time a sprayer is sold, the current inspection certificate of this sprayer should be handed over to the new owner.
2.5. Financial aspects

The services organising the mandatory inspections are fully self-supporting: the contributions of the farmers for the inspection of their sprayers are used to pay the personnel, the running cost and the periodic replacement of the test equipment and vans. The initial investment for test equipment (820,000 €) at the start of the inspections was paid by the former Federal Ministry of Small Enterprises, Traders and Agriculture. The inspection tariffs are fixed on such a level that the services can finance their tasks, limiting the costs for the farmer to the absolute minimum. Table 1 shows the inspection tariffs. For field crop sprayers, the tariffs are linked to the boom width.

Table 1: Inspection tariffs

<table>
<thead>
<tr>
<th>Field crop sprayers</th>
<th>Boom width (m)</th>
<th>tariff (€)</th>
<th>Boom width (m)</th>
<th>tariff (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 or less</td>
<td>70</td>
<td>19</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>76</td>
<td>20</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>82</td>
<td>21</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>88</td>
<td>22</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>94</td>
<td>23</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>100</td>
<td>24 or more</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>106</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Orchard sprayers    | always 70 €    |

The costs for a second inspection include always € 12.5 for administration. This amount is increased with € 12.5 and/or € 50 and/or € 25 when the reason for the rejection at the first inspection was due to respectively a defective pressure gauge, worn nozzles or any other defect that led to a rejection. However, the total costs for a second inspection are limited to a maximum of € 62.5. The farmer does not have to pay the higher tariff for a second inspection due to a defective pressure gauge and/or worn nozzles when he voluntarily hands in these parts to the inspectors during the second inspection.

3. Conclusions

Belgium was one of the first countries in Europe to introduce a mandatory inspection for spraying machines. The organisation and procedures have proved in the past nine years to be sound. As increasingly more countries in Europe are introducing a voluntary or compulsory inspection for spraying machines used in agriculture and horticulture the need for harmonisation grows. There is a genuine need for European regulations governing frequency of inspection and procedures. This is also important e.g. in view of the future introduction of the EUREP – GAP regulations. A harmonisation of the test procedures for the inspection of sprayers is essential but efficient testing procedures for some parts of the machines must still be investigated and described.

References

Aspects of the organisation of test sprayers in some Italian regions

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Summary

In recent years many Italian regions are involved in both voluntary and compulsory tests of sprayers already in use. The Agricultural Mechanisation Institute (Istituto Sperimentale per la Meccanizzazione Agricola) has collaborated with the extension services of some regions for establishing the criteria and the organisation of tests. The regional administrations have chosen different organisation of the testing facility networks in which farmers are required to test their machinery, including the possibility to use fixed or mobile testing equipment. A key element in this choice is to satisfy the testing requirements of the territory at a reasonable cost. The paper shows the test methodology, the most important features of the testing devices, the most common problems occurring on the controlled sprayers and the future development of the regional projects. Some examples are also given from Campania, Latium and Tuscany regions. A mix-integer mathematical programming model developed to choose the best organisation of the testing facility network in an area is also presented.

1. Introduction

A key element in the reduction of chemicals employed in plant protection is the utilisation of appropriate, efficient, safe and well maintained sprayers. Each step, from the choice of the new machinery to the maintenance of sprayers in use, has to be properly checked in order to enhance pesticide application and distribution efficiency, to minimise costs and to preserve the environment.

This concept is now widely accepted and for this reason in recent years many Italian regions have started programs aimed at the testing and the inspections of sprayers already in use.

The Agricultural Mechanisation Research Institute (Istituto Sperimentale per la Meccanizzazione Agricola ISMA), has collaborated with the extension services of some regions for establishing the criteria and the organisation of tests.

2. National reference methodology

The Italian Ministry of Agriculture financed a two-year programme, called "Agricoltura e Qualità" (Agriculture and Quality) to support the development of sprayer testing at a regional level. A total of 14 regions carried out this programme and the co-ordination of this programme was assigned to ISMA. Moreover, a working group of experts, including researchers, technicians and regional officials was created to assist the co-ordinator in each step of the project (Biocca and Vannucci, 2000). The principal result of the programme was to establish a "national reference methodology" in which are indicated the tests, the limits of tolerance, standardisation of controls and basic indications on testing apparatus.

This methodology is widely employed in controls in Italy but since the existing equipment was often more defective than expected, a new methodology was suggested by ISMA and then adopted in two regions: Latium and Tuscany.

Table 1 summarises this methodology.
Table 1: Test methodology for the Latium and Tuscany regions.

<table>
<thead>
<tr>
<th>Component parts</th>
<th>Tolerance limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boom horizontality</strong></td>
<td>15 mm per 1 m boom length</td>
</tr>
<tr>
<td><strong>Filtering</strong></td>
<td></td>
</tr>
<tr>
<td>1) Right types</td>
<td>Visual</td>
</tr>
<tr>
<td>2) Wear</td>
<td>Visual</td>
</tr>
<tr>
<td>3) In sucking installed</td>
<td>Recommended (1)</td>
</tr>
<tr>
<td><strong>Tank</strong></td>
<td></td>
</tr>
<tr>
<td>1) Level indicator</td>
<td>Visual</td>
</tr>
<tr>
<td>2) Cover seal</td>
<td>Visual</td>
</tr>
<tr>
<td>3) Drainage</td>
<td>Visual</td>
</tr>
<tr>
<td>4) Agitator</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>Pipe system</strong></td>
<td>Visual</td>
</tr>
<tr>
<td><strong>Anti-drop</strong></td>
<td></td>
</tr>
<tr>
<td>1) Installed</td>
<td>Recommended (1, 2)</td>
</tr>
<tr>
<td>2) Functionality</td>
<td>Less than 10 s of dripping</td>
</tr>
<tr>
<td><strong>Pneumatic pressure pulsation damper function</strong></td>
<td>Visual</td>
</tr>
<tr>
<td><strong>Manometer</strong></td>
<td></td>
</tr>
<tr>
<td>1) Position (visible from the tractor)</td>
<td>Recommended (1)</td>
</tr>
<tr>
<td>2) Measure units</td>
<td>1 bar up to 15 bar (field sprayers); 2 bar up to 20 bar (orchard sprayers)</td>
</tr>
<tr>
<td>3) Diameter</td>
<td>&gt;= 63 mm</td>
</tr>
<tr>
<td>4) Precision</td>
<td>Less than ± 5; ± 6; ± 7 % depending on pressure value</td>
</tr>
<tr>
<td><strong>Nozzle output</strong></td>
<td></td>
</tr>
<tr>
<td>Single nozzle</td>
<td>Less than ± 15 % (field sprayers); Less than ± 5 % between right and left side (orchard sprayers).</td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
</tr>
<tr>
<td>Uniformity (field sprayers); Less than ± 20 % at each measured heights between right and left side (orchard sprayers).</td>
<td></td>
</tr>
</tbody>
</table>

(1) “Recommended” means that the lack of the components is tolerated in the first inspection but it is requested to have them installed before the second inspection;
(2) In Tuscany, anti drop devices are requested also in the first inspection.

3. Regional development of the periodic controls

The difference in the testing protocol is not the only one in the organisation of inspections in Italy. In fact, depending on the regions, both public and private inspection teams are in charge of controls, thus, a large variety of local organisations structures can be found. Furthermore, different testing facilities are used for the measurement and controls, especially if controlling the vertical distribution pattern of sprayers for fruit trees and vineyards, where both tray and lamellae patternators are largely used.

However, some common elements in the development of a well established periodic control of sprayers in use are easily recognised in all regions and these steps are a sort of guide pattern for regions who want to create a new inspection service.

In our opinion, in the first phase, it is necessary to inform each “stakeholder”, including farmers, on what an inspection is and what controls consist of.

Then it is suggested to begin some demonstration activity and, in the meantime, to train technicians and experts.
The initial inspections have to be just voluntary, then conditionally compulsory (i.e. agri-environment measures in rural development) and finally they will become compulsory for all sprayers. These first steps of development are supported in each region by local universities or research institutes in order to grant technical and scientific assistance for the regions in different fields (i.e. methodology of controls, choice of testing equipment, training of technicians and so on). Finally, the service becomes self supporting and private subjects are involved (i.e. private workshops). Nowadays, we observe in Italy a large variety of organisations depending on the phase of development of each region.

4. Examples from some regions

ISMA has collaborated with some Italian regions for technical and scientific assistance. In the following paragraphs some examples of actual organisation which are testing sprayers are given, with special emphasis to the specific aspects developed in different areas.

4.1 Latium

In this region the first voluntary controls started around 1997 when ISMA realised a mobile testing vehicle. The choice of a full mobile equipment makes it possible for the service to cover the total regional area and it is very useful to make the service known to the farmers. Nowadays in Latium there are about 30392 sprayers, with a density of 0.028 sprayer/ha and about 13.9 % of the machines are ten years old or older (ISTAT 2002). After a first phase with only a demonstration activity, the testing of sprayers in use became conditionally compulsory for the farmers who grow crops according to E.U. agri-environmental measures. Because during the first controls sprayers were found to be extremely defective (especially in gauge precision, nozzle output uniformity and other characteristics) a special methodology, based on the national reference guidelines, was set up in order to make controls easier and faster. This methodology classifies defects as minor (those not requesting a second inspection) and major. If a major defect is found, the inspection is stopped and the farmer is invited to a second control after the defects are fixed. Moreover, a special rule for the admission of machines to the inspection was introduced in order to encourage the farmer to inspect the sprayer himself before the official inspection. In fact, the testing centre accepts the sprayers only if the following requirements have been met:

1. Clean sprayer.
2. Boom nozzles have to be identical and mounted at the same distance from each other.
3. Properly working pump.
4. Clean water in the tank.
5. No visible leakage.
6. Possibly the same tractor used for field operations.
7. Manometer with diameter >= 63 mm.
9. Manometer with adequate units of measure (at least 1 bar for field sprayers and 2 bar for orchard sprayers).
10. The farmer may know the use of the sprayer.
11. Easily removable nozzles.
12. Respected sprayer security standards.

Nowadays in the Latium region there are 15 semi-stationery centres (three for each province). In the near future, it is likely that the controls will be managed by private subjects.
4.2 Tuscany

In this region a demonstrative activity started in 1991, thanks to a collaboration between ARSIA (Regional Agency for Agriculture Innovation and Development) and the University of Florence (Vieri and Russu 2003). In 1995, the first Italian prototype of a vertical patternator based on vertical lamellae technology was realised.

In Tuscany there are 22600 sprayers (with 0.014 sprayers/ha, 22.6 % of them are older than 10 years) (ISTAT 2002).

In the past years ARSIA has collaborated with ISMA to set up a regional network of seven control centres.

ISMA has also realised the testing equipment, including a vertical bench based on vertical lamellae patternators.

Nowadays Tuscany is the only region where the inspection of field sprayers is compulsory, according to a regional law (L.R. n° 36-1/07/99).

The methodology applied during the controls is based on the national guidelines and it is very similar to Lazio methodology.

4.3 Campania

This region has 30392 sprayers, with 0.058 sprayers per hectare, 17.2 % of the sprayers are older than 10 years (ISTAT, 2002).

In Campania controls are only voluntary and so far the programme is based only on a demonstrative activity. For this reason a full mobile equipment was preferred, in order to carry through inspections all over the region. The teams in charge of inspections are public (technicians of the regional extension services).

In the near future a new stationary centre will be realised and the controls will be entrusted to private workshops.

5. The mathematical programming model

The organisation of a testing facility network should be aimed at satisfying the testing requirements of a region at reasonable costs. However, this is not a simple task because it requires to explicitly consider the cost of each organisation scheme, how many pieces of machinery must be tested each year, the possibility to use fixed or mobile testing equipment. This last choice is directly influenced by the location of farm machinery in the different parts of the region. Fixed equipment can often perform more testings per year than mobile equipment, but imposes more costs on farmers who are required to move their machinery to the testing centres. Mobile equipments, while more expensive for the administrators of the testing facility, can reduce farmers' costs by taking the testing equipment to the more remote farm areas.

A mix-integer mathematical programming model has been developed to support regional administrations in choosing the best organisation of the testing facility network, considering the spatial characteristics of the region (Brooke et al. 1999). The model identifies the number and kind of testing equipment for each location that, satisfying testing requirements, minimises the annual costs of the testing service. This can refer just to the costs incurred by the regional administration in charge of the service or, alternatively, to the sum of both administration and farm costs.

The model has been applied to a Latium province (Viterbo), considering the distribution of spraying machinery in the 60 lower level administrative areas into which it is divided (Comuni, in Italian) (ISTAT 1992). The model has suggested the best choice in terms of number, kind and location of pieces of testing equipment in the study area according to different criteria (Severini and Biocca 2003).

Simulation results suggest that this kind of model could be a useful support to design the testing network. In fact, if supplied with adequate data, it provides accurate estimates incurred by both testing equipment administrators and farmers. Furthermore, this kind of model is relatively flexible: it can be adjusted to include different choice criteria and adapted to areas with different characteristics.
6. Conclusions

The inspection services of sprayers in use in Italy appear to be characterised by a large variety of regional situations, depending on both, basic differences in terms of condition and average age of sprayers and on the different levels of development of the sprayer testing service. For these reasons it is possible to find differences in the methodology and equipment and an insufficient number of trained and experienced teams in some regions.

In our opinion, new programme activities, both at regional and national level, will be indispensable in the next future in order to achieve more general standards based on EN 13790 the goal of which is the creation of an inspection of sprayers in Europe of equal quality. Moreover it will be useful to support the administration in the design of testing networks on the basis of sound economic criteria. To illustrate this aim this paper shows a possible use of mathematical programming.

References

Organisation of sprayer inspection in Baden-Wuerttemberg

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Summary

Since the introduction of the compulsory inspection of field sprayers the Federal State of Baden-Wuerttemberg has an administrative regulation for sprayer inspection of the State Ministry of Nutrition and Rural Affairs which was renewed in 2003 after compulsory inspections of sprayers for vineyards, orchards and hops had been included.

The organisation of the sprayer inspection is carried out by the Plant Protection Service, while the inspection of sprayers is carried out by officially approved workshops.

Beside the State Institute of Plant Protection, four state district administration authorities and 35 boards of agriculture are involved in the organisation of sprayer inspection.

The boards of agriculture are responsible for the execution as well as for checking the plant protection equipment.

The main task of the state district authorities is the recognition of the workshops for sprayer inspection and supervision. For this purpose they normally use the report of experts.

The State Institute of Plant Protection trains these experts and the teaching personnel of recognised institutions.

1. Organisation

In Baden-Wuerttemberg the compulsory inspection of plant protection equipment is organised by the Plant Protection Service, according to the “Administrative Regulation for the Execution of § 7 of the Regulation on Plant Protection Products” of the State Ministry of Nutrition and Rural Affairs of April 2003.
The boards of agriculture are responsible for the execution as well as for checking the plant protection equipment if it is inspected.

The state district administration authorities recognise the workshops for sprayer inspection according to the specified conditions and they supervise them. For this purpose they may use the report of experts.

The inspection personnel are trained every three years according to a list of subjects by institutions recognised by the State Institute of Plant Protection. Additionally, the institute trains the teaching personnel of these institutions and gives instructions to the experts.

![Diagram](image)

**Figure 1**: Organization of the Plant Protection Service of Baden-Wuerttemberg.

The inspection of sprayers according to the administrative regulation is carried out by officially approved workshops. Every workshop which wants to inspect sprayers in Baden-Wuerttemberg has to make an application for approval at the responsible state district administration authority. There is a charge on approval. Each workshop may have several places where inspections are carried out. At present there are more than 400 inspection places in Baden-Wuerttemberg.

### 2. Obligations of the inspection workshops

The management and the inspection personnel must be reliable.

The workshop must employ sufficient personnel who are especially qualified for inspection of plant protection equipment.

Changes in the management of the workshop and the inspection personnel have to be reported to the state district authorities.

The workshop must allow the inspection personnel to join the training courses every three years.

The workshop has to guarantee readiness for the inspection of those sprayers for which it is compulsory.

The workshop must give officials access to the inspection facilities and ongoing work during customary business hours and give information concerning the inspection procedure upon request.

Every inspection place requires a suitable indoor or outdoor testing area. Suitable also means protection from the weather and that the water used during inspection is collected and returned to the sprayers or is disposed of legally.
If the workshop is approved it must use a plate of approval, figure 2. The names of the workshops are published in the official gazette. The approval may be terminated by the workshop.

The workshop must have the following equipment to carry out the inspections:

- devices to measure the pump volume flow rate and to test flow meters,
- a pressure gauge testing device,
- at least two gauging cylinders for calibration,
- a revolution counter,
- a stopwatch,
- technical aid to check nozzle spacing and angles,
- a calculator,
- a patternator to measure the horizontal distribution of field sprayers,
- equipment to measure the nozzle discharge of other sprayers.

The inspection equipment must fulfil the “Requirements for Facilities to Test Plant Protection Equipment Already in Use” of the Guideline 1-3.1.1 of Part VII of the BBA Guidelines for Testing Plant Protection Equipment.

To ensure the necessary accuracy of measurement, the complete equipment must be checked by the experts at least every two years. The result of the tests has to be reported in an instrument book. All tested components are labelled with a sticker. Additionally, the regulations of the calibration law have to be considered for the pressure gauges.
The sprayer inspections have to be carried out accurately and reliably according to the “Features for Testing Field Sprayers and Air-assisted Sprayers Already in Use” of the Guideline 1-3.2.1 of Part VII of the BBA Guidelines for the Testing of Plant Protection Equipment and according to further approval regulations.
3. Inspection report

The result of inspection has to be reported for every piece of plant protection equipment in writing, in at least two copies. Especially faults have to be reported. The inspection reports have to be treated confidentially. The original of the report is handed over to the owner of the equipment. The respective inspection workshop keeps its own copy for four years.

An overview of the inspections and the results has to be sent to the state district authorities twice a year, using a form of the state institute of plant protection.

4. Inspection stickers

The inspection workshops obtain the stickers at their expense. They award the inspection stickers according to § 7 of the regulation on plant protection products. They keep records about the use of the stickers for four years. These records have to be submitted to the plant protection service twice a year.

The material of the sticker is a self-adhesive foil with a size of 75 mm in diameter. The colours are identical with those of official inspections of motor vehicles in Germany.

![Figure 5: Inspection sticker.](image)

<table>
<thead>
<tr>
<th>Year of next inspection</th>
<th>Colour</th>
<th>RAL (standardised) No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Brown</td>
<td>8004</td>
</tr>
<tr>
<td>2005</td>
<td>Pink</td>
<td>3015</td>
</tr>
<tr>
<td>2006</td>
<td>Green</td>
<td>6018</td>
</tr>
<tr>
<td>2007</td>
<td>Orange</td>
<td>2000</td>
</tr>
<tr>
<td>2008</td>
<td>Blue</td>
<td>5015</td>
</tr>
<tr>
<td>2009</td>
<td>Yellow</td>
<td>1012</td>
</tr>
<tr>
<td>2010</td>
<td>Brown</td>
<td>8004</td>
</tr>
</tbody>
</table>

In the following years, the colours are repeated in the same order. The colour of the writing is definitely black. Size of the inspection workshop’s address field: 60 mm wide, 25 mm high. The address of the inspection workshop, written in black, may be either directly printed on the sticker or is stuck separately on the address field in the inspection sticker with self-adhesive transparent foil.
Experiences of introducing an inspection system for orchard sprayers in Sweden

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Summary

Swedish commercial fruit production is concentrated in the Southern region; Scania. There are about 2 200 ha of tree fruit, of which 1 700 ha are apples, an increasing acreage of pears, and some plums and cherries. Fan sprayers are used for plant protection in all tree fruit crops. There is also a limited use of fan sprayers in some berry productions (blackcurrant) and field nurseries.

We estimate the maximum number of commercially used orchard sprayers to be about 300, plus about 50 very old and rarely used ones.

Swedish (and Danish) growers have a tradition of using Schaumann orchard sprayers. The sprayers are produced in Denmark and the basic design goes back to the 1960s. The most common model has an axial fan with two radial air outlets, centrifugal pump, mechanical agitation, and a twin fluid swirl nozzle type (compressed air and spray liquid meet in a mixing chamber). Newer models exist, with four air outlets (two in higher positions) and also with tangential fans. According to growers, Schaumann sprayers are known to be very durable and easy to maintain. This might prevent growers from replacing their sprayers with other makes.

Other orchard sprayers (about 10 %) reflect a common mix of European sprayer products; Holder, Douven, Hardi, Lochmann, etc).

1. Beginning of sprayer inspection

As presented on a poster at this workshop (Sandström 2004), between 1988 and 1999 Sweden had a government supported programme for conducting voluntary inspections of boom sprayers in use. The inspections and investments in test equipment were partly subsidised by the state. Orchard sprayers were not included in the programme. Integrated Production (IP) was introduced around 1990, and a solid majority of Swedish fruit growers are associated. From the very beginning IP-regulations prescribed an inspection every second year (if an officially approved test procedure exists).

2. Initiative of the Swedish board of agriculture

During 1996, the Swedish Board of Agriculture commissioned the Department of Agricultural Engineering (LT) at the Swedish University of Agricultural Sciences (SLU) to investigate the requisite for introducing a voluntary inspection for orchard sprayers as well.

After studying the respective literature, visits to important regions in Europe with inspection activities, and discussion with Swedish growers, advisers and authorities, a proposal for future voluntary orchard sprayer inspections was presented (Svensson and Hagenvall 1997). It contained two parts; one part dedicated to the safety and mechanical features of the machine and the other part dealt with operator controlled factors, such as calibration, adjusting and information.

The first part was rather traditional and was based mostly on existing European procedures at time. The vertical patternator was used in many of the European inspection activities. Even if this equipment was interesting and had advantages for adjusting the sprayers, it was excluded from the Swedish proposal of procedure. It was regarded as too expensive in relation to the number of orchard sprayers, and, at that time, difficult to transport.

The second part focused on information and education. An important benefit was noticed in the case of boom sprayer inspections, where the inspections were made on a farm, including a calibration procedure. This resulted in a properly set up and calibrated sprayer with the grower involved in the adjustment process. This hands-on training was even more important for orchard sprayers with an increased number.
of adjustment parameters. The fact was also demonstrated during our visits to, for example, Lleida (Spain), Gleisdorf (Austria) and Norway.

Thus, after the sprayer was put in acceptable technical condition, the proposal included an advising part, where the grower and adviser calibrated the sprayer for different plantation types and conditions. This included an instruction on how to use water sensitive papers and how to limit wind drift by adjusting air jet directions and by nozzle choice. At the end, the grower should have a sprayer of a good technical standard, a set of tables with sprayer settings for different situations/parts of the orchard, and knowledge of how to use water sensitive papers.

3. Education of inspectors for orchard sprayers

In October 1999, the Board of Agriculture, in co-operation with the regional Agricultural Department of Scania, financed a three-day course for potential inspectors of orchard sprayers with invited experts and test equipment from Poland, Norway and the USA. Many boom sprayer inspectors were interested, together with advisers and representatives of the PPP-industry. A vertical patternator was leased from Poland, and different settings and changes were demonstrated and discussed. The group exercises in field were also appreciated. In summary, at that time the course constituted a good platform for a future voluntary inspection programme as part of the existing Integrated Production rules.

4. Changing the conditions

However, almost simultaneously, late in 1999, the general subsidies for sprayer inspections were withdrawn, except for investments in testing equipment. This resulted in a situation where, from a legal point of view, there was no longer any formal incentive for a state support or backup of an orchard sprayer inspection procedure.

Since then, the sprayer inspection initiative was up to the IP-Organisation. Almost nobody of the fruit industry or grower organisation received updated information on the CEN-work. Rumours created confusion as preliminary versions of EN 13790-2 disagreed with the proposal presented earlier.

5. Initiative of integrated production

Eventually, after a long discussion about how regulations should be expressed, leading growers in 2002 decided to sanction a test procedure for inspections of orchard sprayers, as part of the IP-activities. The procedure is based on the EN 13790-2 with some exceptions. Sprayers should be inspected every second year, starting 2003 (= all IP-sprayers should be inspected not later than the end of 2004). The Schaumann nozzle type became a problem as it is difficult to add on a drip-stop-valve without redesigning the sprayer liquid system. This nozzle type was exempted from inspection for two years.

6. Results until now

The inspections had a very slow start with less than five sprayers being inspected in 2003. This year during spring 2004 the sprayers were lining up for inspection. Just one or two companies are active on the orchard sprayer inspection market which will most likely create problems at the end of the year.

The fact that the inspections really started after so many years of discussion released an increased interest to modernise the Schaumann sprayers. One company now offers a very interesting complete remodelling, including a hydraulic powered modern pump, modern standard nozzle bodies with drip-stop valves, hydraulic agitation, internal rinsing nozzle, fresh water tanks for in-field-rinsing, remote control, etc (Folke Persson, personal information, 2004).

The inspection activities will hopefully replace many faulty nozzles, incorrect pressure gauges and pressure controls, as well as leaking hoses and improper tank agitation blades. We expect that several old sprayers in bad condition will disappear from the market. We also expect regional environmental authorities to order that all sprayers used within water protection areas have to be inspected.

Finally, for the future we expect the European standard procedure (EN 13790) to be introduced.
Acknowledgements

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References


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Compulsory inspection of sprayers in use: improving efficiency by training and formative aspects

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Summary

Taking as a reference the methodology of sprayer inspections in use in Europe, a special incentive has been developed in two important vineyard areas of Spain. The main characteristic of these incentive is the training of farmers. Thus, not only a detailed inspection of all sprayer components has been developed (including the possibility of replacement of specific elements such as nozzles or manometers), but also, according to the particular conditions, a regulation process has been developed where the most suitable working conditions are taken into consideration. The most interesting conclusion is that defaults in the application process are basically the result of a lack of knowledge on the part of the farmer of the adequate parameters for spray application and not mainly because of the general condition of sprayers.

1. Introduction

Compulsory inspection of sprayers in use has been widely implemented in several countries of the UE with the aim to control the state of sprayers in use and consequently to improve the quality of applications. In all cases in which the responsible inspection staff must decide about the aptitude of the inspected sprayers, only quantifiable measurements can be carried out which serve as decision guidance. In this sense the EN 13790 has been assumed as a general guide.

In other circumstances, as i.e. voluntary inspections carried out by technicians and researchers from the universities, aspects so important as training farmers have been included in the inspection procedures. The aim of this paper is to show the importance of increasing farmer’s knowledge in all the aspects involving inspection and use of sprayers. More than 150 sprayers have been inspected in Spain using a combination of technical measurements and formative actions. The objectives of these incentives have been to check technical aspects of sprayers and substitute fundamental parts if necessary (nozzles and manometer), to measure and validate the application characteristics used by farmers and finally, to improve the knowledge that farmers have about calibration techniques.

Results of different works with the aim to establish the actual situation of sprayers in use carried out in different areas in Europe show two main aspects which are worth mentioning: the actual sprayers in use fall in most cases below the minimum quality parameters; important defaults have been detected in most of the principal components, like nozzles, manometer, level indicator, PTO protections,… (Val et al. 1988); on the other hand, very important deficiencies have been observed in all the aspects related to maintenance and regulation processes of sprayer equipment, as a consequence of a considerable lack of knowledge of farmers (De Zanche et al. 1993).

This type of activity, in which information and inspection have been developed together, show that most problems are directly related to the conditions of use, with great defaults on the sector of selected working pressure, inadequate forward speed, total lack of nozzle replacement and incorrect adjustment of air flow.

2. Methodology of work

More than 150 sprayers in use have been inspected in two different periods in two important producer areas in Spain: Penedes (Barcelona) and Campo de Borja (Zaragoza). The developed activities have been structured in four different steps:
2.1 Previous information

A theoretical session (half day) was organised in one of these incentive areas (Campo de Borja) previous to the inspection programme. In this short training course the theoretical aspects about calibration procedure, nozzle selection, maintenance of sprayer, etc. were developed to clarify the importance and the direct relation of working conditions and final result of applications.

2.2 Acquisition of data about farm and crop characteristics

Specific interviews were developed in order to obtain specific information about farm characteristics (size, level of dispersion of parcels, main distance to water source, crop distribution, number of treatments per year, etc.) and also for data acquisition about the main crop on the farm (in this case: wine) with special attention to varieties, trellis system, plantation density, etc.

2.3 Checking of sprayer components

Several incentives were made at this third level in order to check the main components of the sprayer tested. A combination of visual and measured determinations was developed, table 1. Visual inspections were carried out according to a pre-established scale of evaluation, going from value 0 (very bad) to 5 (very good). Measured determinations were conducted for the most important components of the sprayer:

- **Nozzles**: the individual flow rate was measured for every nozzle on the sprayer and this value was directly compared with theoretical values according to the nozzle catalogue. This determination was made for two different pressures, a reference pressure following manufacturer recommendations and for the working pressure established by the farmer, in order to know the real application values.

- **Manometer**: 20 different steps were established (from 0 bar to 20 bar and from 20 bar to 0 bar, every 2 bar) at which the measured pressure on the sprayer's manometer was compared with the measured pressure on the reference manometer, in order to establish the real deviation.

- **Fan**: according to the different characteristics of sprayers, a variable number of control points was established on the left and right side of the air outlets in order to determine the amount and the variability of air flow (air speed and air flow rate). All these determinations were made at the PTO speed commonly used by farmers.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Visual</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air distribution</td>
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<td>✓</td>
</tr>
<tr>
<td>Fan</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Liquid distribution</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Manometer</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Nozzles</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>PTO rev</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Agitation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Blower</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Filtering</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Pipes and hoses</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Power transmission/blower</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Pump</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Regulation system</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Spray tank</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

As a main difference from what is normally carried out in the conventional inspections, the possibility to change nozzles and manometer was offered to the farmers. In this case, a special price reduction (50 %) was made in collaboration with two Spanish manufacturers of these components (Ilemo-Hardi, S.A. and SEP, S.A.).
2.4 Adjustment of sprayer and use guideline

In this final action two different steps were established: determination of real conditions of applications and regulation of the sprayer according to these specific conditions (including the determination of vertical distribution):

Determination of real application parameters: on the basis of obtained data about the real nozzle flow rate at working pressure selected by farmer, tests were conducted in order to measure the real forward speed (maintaining the condition proposed by the farmer about PTO speed and gear relation). After that the real value of the applied dose (l/ha) was obtained.

Sprayer adjustment according to the specific conditions: once all measurements were recorded and after the substitution of components where needed, the most suitable working conditions (applied dose, working pressure, type of nozzle, forward speed, PTO speed and air speed) were selected according to the particular conditions of the crop. As a final determination, the vertical distribution obtained with the new conditions was checked using a portable vertical patternator developed by the Agricultural Machinery Area of Escola Superior d’Agricultura de Barcelona (Gil et al. 1996).

At the end of the process, which takes an average of 2 hours/sprayer, a complete dossier including the final result of all determinations and a specific guideline about working conditions is delivered to the farmer, fig. 1.

3. Results

An important difference in the interest shown by farmers has been detected in the two evaluated areas. The organisation of a previous short training course in Campo de Borja had a determinant influence on the farmer’s response. About 90% of them inscribed their equipment for the voluntary inspection, while in Penedes, without having held a previous technical course, only 24% of the contacted farmers were
interested in the programme, fig. 2. Information flow seems to be one of the most important tools for the final goal of this kind of activities.

The age of sprayers is not a problem. Results show that more than 73% of inspected sprayers were less than 10 years old, and 48.5% were less than 4 years old. As for the operation capacity of the different components, the emitted flow rate in 75% of the checked nozzles differs more than 20% from the values indicated in the nozzle catalogue. This fact can be attributed to the age of the nozzles, taking into account that more than 55% of the checked nozzles is more than 3 years old, and 41% is more than 5 years old.

![Figure 2: Differences in the interest of farmers if a previous technical course is held (right) and without the previous course (left).](image)

About 90% of tested manometers show differences in respect to the reference manometer (in most cases values exceeding the standard value) and more than 75% of them have an inadequate scale (0-100 bar) with a poor resolution level.

The most important problem found in air distribution are the too low air speeds detected in hydro pneumatic sprayers, due mainly to the wrong PTO speed selected by farmers.

Components as pipes and hoses, filtering system, tank, and PTO protection, offers different values of appreciation, fig. 3. A special comment on level indicators on the tank has been made, where more than 90% of the sprayers showed deficiencies. In all cases, the level indicator is a translucent band placed on one side of the tank.

![Figure 3: Most important defaults observed in components.](image)
But the most important aspect to analyse are the inadequate working conditions selected by farmers during the application process, fig. 4, as a consequence of a lack of knowledge regarding the calibration process. In 67% of the cases the working pressure selected was exceeding the recommended limits for orchard and vineyard applications (5-15 bar) with a tendency to use even higher pressure, fig. 5, the forward speed was not in accordance with the particular conditions of sprayer and crop in 42% of analysed cases, fig. 5, PTO speed was deficient (too slow) in 45% of sprayers and in 48% of the cases the actually applied volume was different to the one aimed at by the farmer.

![Figure 4: Percentage of inspected sprayers with important defaults in the selected working conditions.](image1)

![Figure 5: Measured values of forward speed (left) and working pressure (right).](image2)

Finally, from the different questions posed to the farmers, we can selected the answers concerning regulation frequency. On average, more than 68% had never before calibrated the sprayer and only 12% used to calibrate the sprayer before every application. These values change with different parameters, mainly according to the farm size, fig. 6.
At the end of this activity, more than 600 nozzles and more than 70 manometers had been replaced, selecting the adequate models according to the specific conditions.

4. Final considerations

The most important defects detected in sprayers are related to the main components, such as nozzles, manometers and tank level indicators. Thus, an immediate solution of these problems can be achieved by the \textit{in situ} replacement of these small components. These activities, in which information and inspection have been developed together, show that most problems are directly related to the conditions of use, with great defaults on the sector of selected working pressure, inadequate forward speed, total lack of nozzle replacement and incorrect adjustment of air flow.

Most farmers have a lack of knowledge about the calibration process which makes the final success of the applications questionable. The item most appreciated by the user is the final guidebook, which gives specific information about the sprayer and the most suitable conditions of use. A special follow-up inspection of inspected sprayers confirms a reduction of about 30\% of the formerly applied dose in the most effective and efficient applications, with direct consequences for the final quality of products (grapes).

The most valuable item for the farmer is the final guidebook, which gives specific information about the sprayer and most efficient methods of use.

References


Results Session 2 - Administrative regulations required for establishing an inspection

1. Current situation in the Member States (MS) and candidate countries (CC)
   1. Some countries have already legal regulations for sprayer inspection.
   2. In many MS and CC the inspections are carried out by commercially approved stations or dealer workshops. The administrative regulations are adapted to country conditions (size, regional division...).
   3. Different organisation schemes are used by the MS and CC (private or state inspection stations, national or regional secretariat, national steering committee, certification body for the test station...).
   4. Different responsibility schemes are used by the MS and CC (Who is responsible for what?).
   5. Different schemes for consequences of inspection are used (What happens if the sprayer fails the test?).
   6. Different schemes have been implemented by the MC/CC for training inspectors.

2. Objectives to improve the current situation
   1. To establish administrative regulations which guarantee a high quality level of sprayer inspection.
   2. To establish a European training scheme for inspectors (see Session 4).

3. Need for further actions - short-/long – term
   1. Establishing legal regulations for sprayer inspections on the basis of EN 13790 in all MS. The following shall be considered:
      • the commitment to either voluntary or mandatory inspection,
      • the organisation of inspection,
      • test procedures for sprayers in use and brand new sprayers,
      • the procedure of approval of test stations,
      • the definition of minor defaults, and
      • the consequences of failure.
   2. Exchange of information between inspection services of different countries (ex: repeated problems between countries).
Parameters to consider the implementation of systematic inspection of sprayers

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Summary

The use of pesticides in modern agriculture often remains necessary. However, to improve economic and environmental criteria, it is necessary to ensure the quality of agrochemical products and their application. Every country has a strict legislation concerning the certification of Plant Protection Products (PPPs). These measures are, however, not sufficient. Experience shows that users more or less master all the constraints of plant protection and that only a well-tuned sprayer being in a good working order makes it possible to optimise the treatment. Spraying is the last step before the contact between the PPP and the target.

Given these different reasons, many countries organise inspection of sprayers in use according to different technical protocols and administrative management. The implementation of a systematic sprayer inspection is not easy and requires, beforehand, to consider the objectives and the constraints linked to it.

Several questions must be analysed. What is the aim of sprayer inspection and how to reach it? How many sprayers have to be inspected each year? Who is going to take care of the inspection on technical and administrative points of view? What is the acceptable cost to inspect the sprayer? Who will pay? What is the well-adapted technical procedure and practical organisation suited best for local constraints? Are there any laws on the subject?

Many questions have to be analysed and it is therefore important to have a ready answer to each of them before setting up an inspection in a country. The experience indicates that the choice of technical procedures and the choice of practical organisation are the two main keys if we want to succeed in the implementation of a systematic inspection of sprayers.

1. Introduction

Throughout Europe and the world, official authorities as well as users are trying to rationalise the use of pesticides in agriculture. One of the privileged channels is the periodic inspection of sprayers. Different steps, compulsory or not, are established in many countries in order to test the functioning of sprayers and improve the fleet of equipment.

Compared to compulsory inspection, voluntary inspection is rewarding for technical and organisational skills but generally leads to a less thorough inspection because criteria and acceptance tolerances are little or not established at all and because of a lack of real corrective actions. However, the voluntary phase is an important step allowing to gradually accustomed users to a compulsory inspection.

This transition to the compulsory inspection is not easy. We have to normalise all the inspection criteria and think about create technical and administrative organisations. The financial aspect has to be taken into account also so that the costs will be acceptable for the different parties involved.

The first step in order to carry out a realistic and operational project is to set up a working group in which all people concerned will be represented: official authorities, agricultural research centres, universities, the agricultural trade union, constructors, training centres, etc. This committee will have to lay down clear and precise objectives and analyse the means to reach them as efficiently as possible.

The following text aims at asking some questions to which we have to find a solution in accordance with local situations. The final objective is to get our sprayers performing and safe for the user and the environment.
2. Why a mandatory sprayer inspection?

The first question concerns the usefulness of a compulsory inspection of sprayers. This question is fundamental and the answers given will make it possible to argue for the setting up of such an operation among users, professional organisations but also among decision making parties.

2.1 State of the sprayers stock

Different analyses show that the stock of sprayers is far from being perfect in Europe; 30 to 50 % of field crop sprayers do not pass usual inspections (FAO 2001). In Belgium, only 24 % of the sprayers were in perfect working order before the setting up of compulsory inspection in 1995 (Huyghebaert and al. 1996); in the Netherlands 50 % of the devices are in good working order at their first inspection; this applies to 60 % of sprayers in Italy and 40 % in France (Cemagref 2001).

This is troubling if we consider the requirements of modern spraying techniques, of the progressive evolution of the PPPs, of the reduction of doses and volumes applied by users, and of several PPPs applied in micro dose.

At present spraying requires spraying equipment to be in a perfect working order, with optimum periods of treatment to be considered and high yields to be reached.

2.2 Economic and environmental aspects

The sprayer is the most often used device on an agricultural or horticultural farm; and each improper spraying treatment will have harmful consequences for the costs of a speculation as well as for the environment. To spray an improper dose in a heterogeneous way, to treat inefficiently, and raising the doses to struggle against resistance phenomena have consequences in the form of extra costs of several hundreds of Euro per year for an average farm (Huyghebaert et al. 1999).

The effect on the environment of a device which is in a bad working order is quite hard to quantify, as pollution sources of PPPs are numerous.

By improving the state of sprayers inaccuracies are reduced and the confidence of the user is reinforced who can then avoid using over dosages for safety reasons.

The existence of residues in tanks, which are always difficult to empty, is also reduced with a device for spraying the right volume/hectare.

2.3 Traceability and quality of agricultural and horticultural products

The quality of agricultural and horticultural products is a result of a lack of diseases on fruits and vegetables but also a lack of PPP residues.

Inspections become increasingly stricter which can lead to the refusal of exportation visa and the withdrawal of entire lots during auctions.

On the other hand, the increasing imposition of specifications by big distribution chains or the resort to standards such as EurepGap oblige producers to show the actions he sets up to master PPPs better. The mandatory inspection of sprayers is, together with other quality actions, part of the traceability concept.

The first constraint for the producer when selling his products is not only that he must provide quality, but also that he has to prove this quality to potential customers.

2.4 Public image of agriculture

The agricultural population is steadily decreasing: it only represented 4 % of the working population of the 15 European Member States in 2002 (EU DG-Agriculture 2004). The pressure and the perplexity of the rest of the population increase in comparison with the agricultural world. The recurrent crises of these last years depreciate the image of agriculture and increase the worry of the population regarding agricultural products. Inspections contribute to give a positive image of agriculture and restore the confidence of people. It is however necessary to complete this action with strategical information and an efficient popularisation.
2.5 Rationalisation of the use of PPP and responsibility

Europe is continually rationalising the use of pesticides. European producers and exporters to Europe are subject to new regulations and European measures. Inspecting the quality of spraying devices, new and used ones, is one of the actions that will start in the future (Liégeois 2004, EU report 2002). It is important that countries that wish to improve the use of PPPs are proactive by being ahead of regulation measures.

On the other hand, these inspection programmes should be part of the responsibilities of national governments in order to protect the people’s health and the environment (FAO 2001). Imposing measures which aim at controlling the way PPPs are applied can lead to this objective.

According to these considerations, there is no choice but to accept that in all countries where voluntary inspections are or have been applied, the number of sprayers which have been effectively controlled is quite low. In Europe, only 10 % of the sprayers have been effectively controlled (Ganzelmeier et al. 1998). Moreover, farmers who make a voluntary step are those who are already conscious of the spraying quality.

A real improvement of the working order of sprayers is achieved necessarily by setting up a compulsory or conditional inspection.

3. Purposes and parameters to consider a systematic sprayer inspection

The setting up of a systematic inspection of sprayers firstly aims at improving the functioning of devices. In order to reach tangible results, it is necessary to lay down objectives and identify the elements that will allow to reach them. The idea of a “police inspection” must be rejected, even if it must be rigorous, in order to privilege a useful and efficient inspection. We must not forget the educational aspect of the inspection, but it should not become prominent; the ultimate aim being to inspect the equipment and not to train users.

3.1 To provide users with usable data

Correct and intelligible information must be given to the user concerning the repairs to be done on the sprayer. Once the dysfunctions have been repaired the sprayer must be in a perfect working order, if need be they will be sanctioned by a second inspection.

The provision of efficient information in order to make the repairs, mainly depends on the type of inspection process.

3.2 To carry out precise, reliable and useful measurements

Since May 2003, operators have the opportunity to receive a reference text at European level (EN 13790; 2003) that describes the process to inspect a sprayer reasonably. Minimum precision requirements are made in the text so that measurements are carried out correctly. The way of measuring is however not systematically specified.

The choice of precise, rugged and reliable measuring devices must be privileged. The credibility of the inspection is linked to perfect measurements. Furthermore, in case of a dispute with the user or the equipment manufacturer we must be able to obtain the same results again.

Obtaining credible and reproducible measurements depends on the inspection process and the calibration management of measuring equipment.

3.3 Uniform inspection on the whole territory

Europe more and more intervenes on the agricultural markets and its regulations. It seems logical that producers are subject to the same advantages and constraints in order to keep competition fair. At national level, irrespective of the size and the political organisation, the inspection of sprayers must be homogeneous on the whole territory, so that none of the users is disadvantaged.

The technical procedure and the acceptation tolerances must be perfectly defined and similar for the whole country. The respective organisation chooses the operator who carries out the inspection.
Depending on this choice, operators will be more or less specialised, trained in a similar way, objective in their work, constant in the maintenance of their skill, and managed by a centralised “authority”.

3.4 Reduction of constraints for the user

Setting up a systematic inspection of sprayers inevitably leads to new constraints for the user: moving the sprayer to a special location for inspection, mobilisation of one person and of the device during a given time, additional cost. In order to avoid penalise users and to make the acceptation of such a measure easy, it is necessary to reduce these constraints.

The necessity of moving to the “site” where the inspection is done depends on the size of the territory but also mainly on the type of operator: mobile operators are visiting the user and fixed operators will be visited by the farmer. The duration of the inspection depends on the distance to be covered as well as on the technical procedure applied. The more optimised a procedure is, the more precise are the indications written in the report and subsequently the inspection time and the explanations given in the report will be optimised further. One more time, the choice of the organisation and its efficiency, associated with a performing procedure through reliable measuring equipment strongly influence the inspection cost.

3.5 Reducing the costs and maintaining budgetary balance

To improve PPP sprayings is indisputably going to reduce the treatments' cost. The costs for the sprayer inspection will have to be paid, all of it or part of it, by the user. These costs will be however spread over the entire period of validity of the inspection (2 or 3 years for example) and represent a very small part, in comparison with the advantage linked to a better application of PPP. It is however necessary to limit these costs.

The most important part of the budget of the operators carrying out the inspection is the labour cost (more than 60 %). We must therefore optimise their work by carrying out a maximum of inspections per day and per year. This element is the crucial point in trying to reach a budgetary balance. This amount is mainly going to depend on the efficiency of the organisation, the chosen procedure as well as the reliability of the measuring equipment.

During the first inspection cycle, it is essential to retain a safety margin regarding estimated incomes.

4. Management and organisation of sprayer inspection

We must answer to the questions: 'WHO is doing WHAT (point 5) and HOW', by taking into account the objectives presented in the previous point.

Beforehand, it is necessary to know the local situation precisely, that is, the number of sprayers to be inspected and their type (field crop and orchard sprayer) as well as their geographical location.

Agricultural statistics are an interesting source of information which has to be taken with caution, however.

4.1 Choice of the operators

The first task is to determine the type of operator: public and official authority, agreed dealer of agricultural equipment, private or public operator recognised by an official authority. Operators should not have a commercial interest in spraying equipment. It is useful to find out if the other staff already does a similar job in other sectors (automobile, etc.).

The level of technical skills must be high and similar for all operators. A high level is necessary in order to master the inspection and to be able to find the causes of sprayers' defects. This skill is necessary to clearly explain to the user the malfunctions and to possibly carry out the appropriate repairs. This skill will be maintained and reinforced by a high number of sprayers inspected annually and also by regular training. On the other hand, it would be useful if training include communication skills and conflict management. Users who do not agree with the inspection result are to be treated with tact and professionalism.
The advantages of the public system are: the skills are chosen at the beginning of the job and the entire staff attends the same training; maintenance of the skills by the high number of sprayers inspected annually, centralised staff and information management, guaranteed objectivity and uniformity of the inspection on the whole territory, high flexibility and adaptability (especially concerning the setting up of quality systems), low costs for the farmer.

The disadvantages are: creating an organisation which imposes rules national level which can however be delegated to the level of a specific area or an administrative department. A consequence of the missing infrastructures is a tendency towards mobile stations.

The advantages of a system operating via the agreed dealers are: possibility of immediately repairing the sprayer, presence of a network and infrastructures distributed more or less advantageously on the territory, good knowledge of the sector, less implications of public administration in the practical organisation.

The disadvantages are: presence of two antagonistic activities: impartial control (objectivity) and commercial function (subjectivity), risk of conflict between farmer and customer and dealer, competence is controlled insufficiently, difficult control of the dealer by the administration, difficult recovery of the results when using a standardised format (especially for the administrator manager), uniformity of control not guaranteed, often farmers have to travel long distances if stations are fixed.

The advantages and disadvantages of private operators recognised by an official authority (who are not related with the trade of the sprayers) are located at an intermediate level.

4.2 Fixed or mobile stations

The geographical distribution of sprayers is an important concept as well as the protocol of inspection selected.

If the measurement of transverse distribution is chosen, it is necessary to carry out the measurement in a building sheltered from wind and rain, in a closed hall (EN 13790 : 2003). Permanent stations will be thus privileged. If the measurement of nozzle flow rates and pressures is retained, the choice remains free.

The advantages of the mobile stations are: reduced distances to overcome by the farmers, no time is wasted before inspection of the sprayer, important flexibility, easier vulgarisation/ sensibilisation. The disadvantages are: consequent organisation for planning appointments, need for identifying favourable places to do the inspection, additional work to manage a vehicle fleet.

4.3 Organisation of day labourers

The organisation depends for many stations on the type of operators and the choice of the stations (fixed or mobile). For the latter, it is necessary to invite the users to show up at a precise date and place, to manage a potential second inspection and the imponderable related ones to the defections. It is a difficult step to establish mobile inspection initially, it will however be managed routinely after a complete cycle of control. A load of secretariat must be analysed.

In the case of fixed stations, the same technique can be perhaps used or then to fix free periods of passage for the farmers. It is then necessary to have a permanent worker in the station to be available for farmers showing up without appointment.

4.4 Co-ordination of the operations

Whatever the type of operators carrying out the inspections “on the ground”, it is necessary to employ other staff too. The principle could be as follows: an official authority, on national level or regional level, co-ordinates the entire operation, for example, by means of a board of management with representatives of the administration, inspection centres, agricultural trade unions, etc. This committee takes care of the good course of inspections, fixes the prices, proposes and modifies the regulations, and solves the problems that the operators cannot answer directly. It would be ideal to associate with this management body a committee dealing with recourse and a body of repression. The first, required by the law, makes it possible for the farmers to officially dispute a decision. The second body controls the
proper application of the laws and intervenes in support of the operators on “the ground”; it is very important for the credibility and the viability of inspections.

4.5 Information management

The information provided to the farmer is of primary importance, but it is also essential that usable data are submitted to the managers. The inspection data make it possible to learn from the statistics about the characteristics of the park of sprayers, the owners, the results of controls. These conclusions are useful for the operators, the authorities, and the manufacturers of equipment.

The compilation of the data on a higher level is only possible if information from each operator is submitted electronically using a standardised format.

5. Choice of technical procedure for the inspection

Since May 2003, the European standard EN 13790 proposes a technical protocol to control the field crops and orchard sprayers. It seems convenient that the countries wishing to establish actions of systematic inspection base them on this protocol. This protocol is the result of the work of many international experts and allows a complete and objective checking of sprayers. Some choices are to be carried out for several criteria of the standard; resulting in practical and budgetary consequences.

For each analysed criterion, it is necessary to establish a tolerance margin with a classification of the defect according to its severity.

It remains necessary to choose measurement equipment which is professional, reliable in time and at least avails of the required accuracy details given by the standard. In addition, it is essential when planning the work, to fix the days specifically dedicated to the calibration of the measurement equipment. The periodicity depends on the intensity of use, but an annual calibration is not sufficient in many cases.

The accuracy, the reliability and the repeatability of the measurements are essential in order to be credible and irrefutable in the event of litigation with the farmers or the manufacturers of equipment. This credibility is reinforced by a periodic and regular calibration with traceability of the operation (procedure, reports, etc.).

6. Conclusions

Well established systematic inspections can contribute to reduce the quantity of used pesticides and to improve the safety and the efficacy of the PPP. These actions should be implemented in all countries while being adjusted to local situations, taking other measures such as training of users and the certification of new equipment into account.

It is essential to analyse the implementation of such an action thoroughly in meetings with all stakeholders concerned, in which clear and precise objectives will be set. For this preliminary step, it is necessary to raise relevant questions and to have concrete and realistic answers which lead to reaching the objectives most effectively.

The preliminary phase of popularisation is essential to reassure farmers but also to make them accept this new constraining measure. Workshops which prepare sprayers before inspection and which repair them must also be made popular; they must know the broad outline of the technical protocol.

The procedure must be applied rigorously, in an impartial way and uniformly in the whole country or region in order to avoid discrimination. The organisation should be effective and as flexible as possible in order to facilitate acceptance of the control by farmers.

The operators carrying through the sprayer inspections must be professional and credible. The main key of success is a high number of sprayers inspected per year by each team/operator.

Follow-up procedures like recourse and repression can take various forms but are essential for a good development and the credibility of inspection in the eyes of farmers and the general public.

Experience shows that in those countries with obligatory and efficient control the quality of sprayers in use is very high.
References
Evaluation of equipment for measuring stationary distribution of crop Sprayers

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Summary

In Norway, the Lurmark patternator has been used when testing crop sprayers for 14 years. Due to a greater focus on other equipment regarding such measurements and the requirements for testing devices recommended in the EN 13790 standards, some experiments to evaluate the Lurmark patternator have been conducted.

The values measured for the 50 mm grooves were also recalculated to 100 mm, in order to compare differences due to different groove openings. The experiments were conducted indoors to avoid drift problems. The spray amount of four nozzles was measured, to ensure collection of the distribution and spray at the edges from the outer fans. The nozzles measured were Hardi 4110-16 flat fan nozzle at 0.2 MPa at 0.40 m nozzle height. Every glass was carefully taken out from the holder and weighed. In this way the collection efficacy was exactly controlled. Three replicates were made, and the distribution curves showed good repeatability. In total, 96.1 to 99.1 % of the flow amount was collected by using the patternator. The patternator also has some disadvantages, but for flat fan nozzles at a height up to 0.50 m and with correct set up and adjustment the equipment proved to be well-suited.

In addition the flow rate for every nozzle is checked in Norway as to uniformity and any nozzle wear.

1. Introduction

In Norway, measurements of spray distribution of crop sprayers have been included in the function test since 1990. In 2000 the government made it mandatory to test all sprayers. Therefore the sprayers have to be tested before 1 January 2006 and then every 5 years. A separate paper distributed during this conference describes the test in more detail (Bjugstad and Hermansen 2004).

Apart from other factors, the EN 13790 standards define requirements according to distribution measuring devices. During the process of agreeing to the standards, one assumption was that the countries that had already implemented a function test programme were not obligated but were strongly encouraged to follow the requirements set by the EN 13790 standards. Norway is still not an EU member but wants to follow the requirements set in these standards as far as possible.

Because the average boom size is short (about 9 meters) and because a visual quick expression of the results is wanted in Norway, the Lurmark patternator has been used in more than 70 different testing trailers with good results. In addition, the equipment has to be moved and set up easily on each farm, mostly one set-up per sprayer.

Some questions have been raised about the exactness and use of the Lurmark patternator. This paper evaluates the Lurmark patternator in respect to measuring the stationary distribution of crop sprayers in Norway.

2. Objectives

The objective was to evaluate whether the Lurmark patternator is a suited testing device for distribution measurement of crop sprayers in Norway. Important parameters to discuss are:

- Exactness,
- Capacity,
- Easy to understand, also for the farmer,
- Reliability,
• Time to set it up,
• Wind sensitivity,
• High flexibility,
• To discover if the system does not act appropriately,
• Low costs.

The experience of the testing operators in Norway is that the patternator has a high capacity, gives a full scale visual picture of the result directly to the farmer, is easy to understand and use, is highly reliable, needs a very short time for set up, is flexible to be set up anew if minor changes in wind conditions occur, damages can be discovered easily, and the equipment is inexpensive. In addition the operators have pointed out that they can demonstrate effects of improper nozzle height and wrong pressure easily for the farmers. After testing about 10,000 sprayers there farmers could accept the results without any problem.

As for other measuring devices, windy conditions outdoors may disturb the result. This patternator measures within a width of 3.0 m. Thus the distribution over this distance is equally measured. Other more expensive devices have a measuring width below 1.0 m. In contrast, the Lurmark patternator has only 420 mm long grooves, and the EN standards point out a need of at least 1.5 m long grooves. This is the main argument against this type of equipment. It is also important to be aware that a minor loss may occur between the middle section and the two side sections. This may interfere with the amount in the neighbouring tubes on each side. Normally only minor differences are found in these values therefore are not taken into account when testing sprayers in Norway.

The experiments presented in this paper were conducted in order to control whether the collection efficacy of a Lurmark patternator is appropriate when measuring the distribution of flat fan nozzles, which are used under almost all circumstances on crop sprayers in Norway.

3. Material and methods

Normally, the Lurmark patternator only gives us a visual and direct picture of the distribution. Reading off exact values would be too time-consuming and difficult for this equipment. The Lurmark patternator has the following specifications (Lurmark 1996):

• depth 420 mm,
• width of grooves 50 ±1 mm,
• tilting during measurements 0º,
• depth of grooves 66 mm,
• top angle on the grooves 30º,
• volume on glasses 98 ml,
• scale on glasses.

To control the patternator, a 3 metre boom section of a crop sprayer, Hardi NK 800, equipped with four 4110-16 nozzles, pressure of 0.2 MPa and nozzle height 0.40 m was used. In order to compare volume collected on the patternator to the nozzle capacity for total nozzle output, the outer nozzles were closed. In this way the distribution was reduced to zero at both edges. Therefore the CV values which are presented later are much higher than accepted, but that is irrelevant for these experiments. Spraying lasted exactly for 30 s. After every trial, every single tube was carefully taken out of the patternator and measured with sensitive scales, type Philips Essence, HR 2394, 1g/5kg. The nozzle capacity of the 4 nozzles was measured for exactly 60 s. The experiment was conducted indoors at a constant temperature of 14 - 16 ºC and relative humidity of 60 – 70 % respectively. When adding every pair of values measured with the 50 mm patternator, a simple simulation with a table of 100 mm grooves was the result. In this way, exact equal values of the distribution pattern for the two different types of grooves were ensured.
4. Results

The results of the experiments are presented in figures 1, 2 and 3, and in table 1 and 2. Figure 1 shows the measured distribution at 50 mm groove spacing. Figure 2 illustrates the simulated values at 100 mm spacing. Figure 3 shows the average curve for the 50 mm and 100 mm grooves. Table 1 shows the calculated STD and VC %, and table 2 the collection efficacy when using a Lurmark patternator. The nozzle capacity of the four nozzles was 1.046, 1.036, 1.043 and 1.042 l/min, respectively. In table 2 the total capacity for 30 s is used in order to compare the amount collected at one time from the Lurmark patternator. The collection efficacy for every measurement was, 96.7, 96.1, and 99.1, and on average 97.3 %.

Figure 1: Distribution of the Lurmark patternator, 50 mm groove distance.

Figure 2: Distribution of the Lurmark patternator, 100 mm simulated groove distance.
Figure 3: Difference in deviation for groove distances of 50 and 100 mm.

Table 1: Average values and CV-values for groove distances of 100 and 50 mm

<table>
<thead>
<tr>
<th>Groove</th>
<th>Series</th>
<th>Average</th>
<th>CV in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 mm</td>
<td>1</td>
<td>68.32</td>
<td>53.47</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>69.01</td>
<td>52.93</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>73.54</td>
<td>52.60</td>
</tr>
<tr>
<td>50 mm</td>
<td>1</td>
<td>34.16</td>
<td>53.30</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>34.50</td>
<td>52.98</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>36.77</td>
<td>52.44</td>
</tr>
</tbody>
</table>

Table 2: Collection efficacy of the Lurmark patternator when measuring every tube

<table>
<thead>
<tr>
<th>Trial</th>
<th>ml/30 s</th>
<th>Output of all four nozzles in ml/30 s</th>
<th>Collection efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2015</td>
<td></td>
<td>96.7</td>
</tr>
<tr>
<td>2</td>
<td>2002</td>
<td>2084</td>
<td>96.1</td>
</tr>
<tr>
<td>3</td>
<td>2065</td>
<td></td>
<td>99.1</td>
</tr>
<tr>
<td>Average</td>
<td>2027</td>
<td></td>
<td>97.3</td>
</tr>
</tbody>
</table>

5. Analysis

The results presented in figure 1 showed a very good correlation regarding replications with the Lurmark patternator. The collection efficacy was higher than expected. This was probably because the experiments were conducted indoors without confounding drift problems. In addition the evaporation was poor. At a height of 0.40 m and using 110° flat fan nozzles, the table collected the spray from the crop sprayer easily.

When using 50 mm groove spacing, a good resolution of the distribution is obtained. This may be seen if figure 1 and 2, which present 50 mm results and simulated 100 mm respectively are compared. In figure 3 this is illustrated even better by comparing the average curves of these two distances. The values for...
the 100 mm simulation are divided by 2 to fit into the diagram for 50 mm values. The figure illustrates that the deviation from average values will normally be higher if the width of the grooves is reduced. Therefore the requirements for distribution in Norway prescribe a maximum of \( \pm 15\% \) for equipment with 100 mm grooves, but a limit of \( \pm 20\% \) deviation of variation when using a patternator equipped with 50 mm groove spacing, like the Lurmark patternator.

Table 1 shows the calculated average values and CV-values for the different methods. The results show very little difference between the CV-values for different groove widths at such a high quantity of values. The collection efficacy in table 2 is very high. This can mostly be explained by indoor testing and steady conditions. The tubes were wetted well and emptied before the tar value was measured. Some water residues may have accumulated on a small scale, but they are regarded to have minor effects. Therefore the collection efficacy was very high. In practical use outdoors, the value will be reduced due to the wind conditions as for all other measuring devices.

6. Conclusions

The Lurmark patternator can collect the major part of the flow, if used properly, when testing flat fan nozzles at a height of 0.40 m. Other experiments have also shown good results, i.e., when measuring at a height of 0.5 m, as we normally do for the air-injection nozzles.

In Norway the testing operator normally visits the farmer at his farm. In some cases 4-5 sprayers are collected at the same location. In addition, the farmer has to participate in the test. When using a Lurmark patternator or a similar device, the farmer and test operator together may discover nozzle failures at once and immediately eliminate them by e.g., cleaning the nozzles, filters, or repairing or renewing the components. In this way the farmer is motivated and understands why the nozzles have to be changed. Normally, the test operator also demonstrates the influence of an improper nozzle height and a different pressure. The equipment is easy to use and very flexible. 70 testing units are equipped with this equipment and the patternator has been used for 14 years. There have only been minor problems or damage.

Disadvantages would be that the CV value is not calculated and that no printout of the distribution is made. However, most of the farmers do not know what a CV value is. Furthermore, a printout of the distribution may lead to some misunderstandings, because this picture may change later on. In any event the farmer gets a protocol showing whether the nozzles are approved or not, which documents that the distribution is below \( \pm 20\% \) deviation, or below \( \pm 15\% \) if a measuring device with 100 mm grooves is used.

If a large number of sprayers are to be tested at the same location, a device like a scanner could be more suited, especially for institutes and special testing stations. But in Norway we will continue to measure as close to the farmer’s own location as possible. The low number of sprayers and the long distances require simple testing equipment and easy handling. In addition to measuring distribution, the flow rates for all the nozzles along the boom are measured. Together with all the other factors and components measured during a Norwegian test, the farmer should be well prepared before the spraying application starts.

Acknowledgements

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Test-bench and computer-aided measurement system for checking and calibrating spraying machines used in “tendone”-trained vineyards.

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Summary

This paper focuses on the design aspects and on the technical solutions for a test-bench prototype to define transversal patterns of distribution of the spraying machines used in “tendone”-trained vines. In addition, also the design aspects and the technical solutions for a prototype which is computer-aided allowing an automation of sprayer inspection and calibrating test procedures are considered. The test-bench is mounted on a trolley approved for road transportation and the intercepting patternator can be folded on the bottom of the trolley by means of an oleo dynamic servomechanism.

The computer-aided measurement system includes i) a measurement bench with sixteen vessels for fluid collection connected to pressure sensors; ii) the computer equipment (computer, data acquisition plug, printer); iii) the software for data management and processing.

The computer-aided measurement system can be connected to:

- either the nozzles of the spraying machine to verify the uniformity of their flow;
- or the test-bench for the definition of the transverse patterns of the spraying machines used in “tendone”-trained vineyards.

In this latter case, the measurement system allows for a comparison between the transverse pattern obtained during the test and the reference pattern adopted.

Furthermore the software specifically designed for this system enables to manage all the other checking operations required by test procedures as well as to create useful archives for the technicians.

1. Introduction

Covering slightly less than 50 % of the total number of vines of the region, the most common and mostly widespread vineyard training method used by Apulian grape growers is “pergolato” training otherwise called “tendone”, fig. 1.

Figure 1: “Tendone”-trained vineyard.
Furthermore, “tendone” training is also largely present in the vine growing sector of the southern regions of Italy with percentages ranging from 40.5% of Lazio to 85.5% of Abruzzo, fig. 2.

Vine-growing for the production of table grapes, which is almost exclusively associated to this form of training, accounts for one of the driving forces of the Apulian farming sector with more than one million t/year of harvested grapes, i.e. 73% of the entire national production (1999).

Now, in consideration of the final destination of product (direct consumption), it can easily be understood how important pest control may be in terms of the equipment, the modalities and the timeliness of treatments.

A well-done and timely treatment can, in fact, enhances pest-control efficiency and avoids the visible surplus on the grapes that may harm the saleability of the bunches of grape.

Therefore the calibration of the sprayers used for treatments in “tendone”-trained vineyards for the cultivation of dessert grapes plays a leading role. For this calibration the intercepting patternator which simulates the behaviour of the leaves and grapes of the tendone during treatment is very important.

The Department of Engineering and Management of Agricultural, Livestock and Forest Systems, (Mechanics Section) of the University of Bari (Italy), that has been carrying out research programmes for a long time, meant to explore the main aspects connected to the use of “tendone”-trained vineyard sprayers, has designed an intercepting patternator for the calibration of the sprayers used in the above treatments.

In a later phase a computer-aided system has been designed for an automatic definition of the transverse pattern of the sprayer.

The study, the design and the realisation of the above equipment were supported by a grant from the Regional Government of Apulia. Furthermore, in this paper some information about a proposal of the Apulian regional service organisation for inspection and calibration of sprayers in use are also given.
2. Realised equipment

2.1 The test-bench

The test-bench for the calibration of the sprayers used for treatments in “tendone”-trained vineyards is essentially made of a droplets intercepting patternator in the shape of the vegetation and productive area of a “tendone” inter-row.

The stainless steel frame of the patternator supports 15 “intercepting” modules. Each one of these stainless steel modules consists of small blades able to intercept the aerosol of the sprayer and is connected to a vessel that collects the droplets, fig. 3.

The patternator is mounted on a trolley approved for road transportation; during transportation the patternator is folded on the bottom of the trolley, fig. 4-a. The calibration operations are carried out when the patternator is positioned as shown in figure 4-b.

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

2.2 Computerised measure system

The computerised measure system includes the following elements:

- measure bench,
- computer equipment (hardware),
- data processing (software).

![Figure 3: Cross section of the intercepting patternator (dimensions in cm).]
2.2.1 The measure bench

The measure bench consists of a welded stainless steel frame with 16 pressure transducers and an equal number of plexiglas containers for the collection of fluids, fig. 5 and 6.

At the end of measuring, the collected water is blown out of the containers through the ball valves. These 16 ball valves are opened and closed simultaneously by a manual stainless steel push rod, fig. 5.

The used transducers (DRUCK mod. PTX 1400) have a measurement range of 0 ÷ 10 kPa and need 12 volt voltage.

Figure 4: a - Patternator folded on the bottom of the trolley; b - Patternator positioned for working.

Figure 5: Front view of the measure bench: 1. victual coupling, 2. polyethylene plate; 3. shackle; 4. welded frame; 5. container; 6. ball valve; 7. sluice; 8. push rod.

Figure 6: Back view of the measure bench: 1. transducer; 2. box of contacts.
The measure bench may be connected either to the patternator for definition of the transverse patterns of distribution, fig. 7-a or, alternatively, directly to the nozzles (up to a maximum of 16 nozzles) for simultaneous measure of their flow rates, fig. 7-b.

Therefore the same transducers are used for both measures.

2.2.2 The hardware

The hardware includes:

- a desktop computer,
- a data acquisition card,
- a portable printer.

2.2.3 The software

The software, specifically made to manage the test bench, starts displaying the main sheet. This sheet contains several data to keep the technician constantly informed on the current state of the hardware as well as on the test operations underway, fig. 8.

In particular the screen displays:

a) tables of relevant databases, fig. 8, point 1;
b) working indicators of each transducer, of data acquisition card and of electric energy, fig. 8, points 2, 3, 4, 6;
c) indicator of the total amount of liquid in the containers, fig. 8, point 5;
d) real time column graph of the level of liquid in each container, fig. 8, point 7;
e) diagram of the water level in the containers during the last five minutes of data acquisition, fig. 8, point 8.
f) Menu items linked to the procedures required for the inspection and the calibration of a sprayer, fig. 8, point 9.


The sheet pertinent to the evaluation of the flow rate of each nozzle is given in figure 9. This sheet is carried out in such a manner as to display simultaneously the measurements made before and after the nozzles adjustments.

![Figure 9](image)

**Figure 9**: Sheet of the software pertinent to evaluation of the flow rate of each nozzle.

It is possible to measure simultaneously up to sixteen flow rates of the nozzles which can be compared with the relevant nominal flow rates under the same operational conditions.

Furthermore, in the above sheet, the measured flow rates are given in the form of coloured column graphs (red/green) to identify the defective nozzles.

The sheet pertinent to the definition of the transverse pattern of the sprayers is given in figure 10.
Figure 10: Sheet of the software pertinent to evaluation of the transverse pattern of distribution of the sprayer.

This sheet is carried out in such a manner as to compare the transverse pattern of the sprayer at the test-bench with the theoretical reference pattern.

The reference pattern is chosen in relation to the geometric and biometric characteristic of the vineyard, using the data stored in the Crops and Training methods archives. The coloured columns of the graphs correspond with the “intercepting” modules of the patternator and are arranged in such a way as to simulate the shape of the “tendone” vineyard. The software calculates, for each “intercepting” module, the difference between the amount of the collected liquid during the calibration test and the corresponding one of the reference pattern. The results are reported as histograms and are placed in harmony with the ones related to the measured pattern. Furthermore, the software enables to carry out all the other inspections and function tests scheduled by the test protocols as, for example, pump capacity, pressure gauge, etc. Finally the software prints out the report with the results of all the carried out inspections.

3. Proposal of the Apulian Regional Service organisation for inspection and calibration of sprayers in use

The preliminary phase concerning the study of the organisation of the Apulian Regional Service for Inspection and Calibration of Sprayers in Use started in 1998 on the initiative of: i) the Phytosanitary Service belonging to the Councillorship for Agriculture of the Regional Government of Apulia; ii) the Apulian Regional Association of Plant Protection Consortia; iii) the Mechanics Section of the Department of Engineering and Management of Agricultural, Livestock and Forest Systems of the University of Bari. Based on the acquired experiences and on the guidelines of other Italian regions where the service for Inspection and Calibration of Sprayers in Use has long been in operation, in the Apulia region it has been suggested that the Regional Service for Inspection and Calibration of Sprayers in Use should involve different bodies in charge of various tasks like the following:

- the Phytosanitary Service;
- the Apulian Regional Association of Plant Protection Consortia (ASSOCODIPUGLIA);
- the Operative Service Centres;
- the Technical-Scientific Institution.
The tasks that should be assigned to the Phytosanitary Service are the following:

- passing regional statutes for the Service and approving the forms;
- monitoring the other involved, above mentioned, bodies;
- issuing the certificates of:
  - conformity of the sprayers;
  - licence of the Operative Service Centres for Inspection and Calibration of Sprayers in use;
  - qualification of the technicians for the above Centres;
- setting up databases of the data collected (certificates of conformity of the sprayers);
- authorising training courses.

The Apulian Regional Association of Plant Protection Consortia (ASSOCODIPUGLIA) should be in charge of the co-ordination of the following services:

- drawing up and printing of paper materials used for checking and calibrating operations;
- transferring forms, cards, stickers as well as legal and technical information to Operative Service Centres;
- organisation of training, promotional, and demo activities;
- filing forms compiled by the Operative Service Centres which indicate what follows:
  - the technical characteristics of the sprayers, and the features of crops and farms;
  - the inspections carried out on the sprayers with the indications of those parameters out of the expected ranges and a list of necessary or “advised” repairs;
  - the final report for farmers.

The Operative Service Centres decentralised on regional territory, represented by the Provincial Associations of Plant Protection that adhere to ASSOCODIPUGLIA, should be in charge of the following tasks:

- carrying out inspections and calibration of the sprayers in use under pre-established protocols at requiring farms or at fixed sites;
- advertising test timetables at the sites: raise the interest of and direct communication to interested farmers in terms of conditions of access to the Service;
- compiling and transmitting forms and documents;
- setting up archives of the documents they are in charge of;
- issuing stickers and final reports and certificates.

The Technical-Scientific Institution, represented by the Mechanics Section of the Department of Engineering and Management of Agricultural, Livestock and Forest Systems of the University of Bari should give the following “support” tasks:

- training activity to award certificates qualifying the technicians for the above Centres;
- periodical checks of the working/conformity of the equipment in use at the Centres;
- technical validation of the Operative Service Centres;
- periodical revision and updating of test protocols and forms;
- periodical processing of filed data.
The equipment and tools made available to date by the Regional Government are the following:

- **n° 5** computer-aided test-benches for inspection and calibration operations of the field crop sprayers. This equipment is used by the five Provincial Associations of Plant Protection;
- **n° 1** computer-aided test-bench for inspection and calibration of the sprayers used for treatments in "tendone"-trained vineyards like the one described in this paper.

The ASSOCODIPUGLIA has also funded the following equipment:

- **n° 3** test-benches for inspection and calibration operations of sprayers to be used for treatments in "tendone"-trained vineyards like the test bench described in this paper;
- **n° 2** computer-aided test-benches for inspection and calibration operations of the sprayers to be used for treatments in espalier-trained vineyards.

The training period of the workers belonging to the Provincial Associations of Plant Protection for the use of the test-benches has ended. The experimental phase of the Service for Inspection and Calibration of Sprayers in Use has also ended. During 2004 the Apulian Regional Service for Inspection and Calibration of Sprayers in Use should be in full operation. The inspection and the calibration of the sprayers in use are at present performed by qualified technicians either at various farms or at authorised Centres. All the activities concerning the inspection and calibration of each sprayer may be subdivided as follows:

**Preliminary Phase:** Advertisement service in the selected area; collection of the reservations; drawing up of the timetable of the activities;

**Phase A:** Selection of the farms; delivery of information material to the interested farmers containing: i) news on the objectives of the Service; ii) minimal conditions and requirements the sprayer must comply with to make inspection and calibration operations possible. During this phase the farmer is “interviewed” to obtain preliminary information to be included in a form focusing on: i) the owner and/or the manager of the farm, ii) the kind of crops, iii) the tractor and the sprayer used, iv) their modalities of use;

**Phase B:** In the selected area. Carrying out of inspections and function tests of the various components of the sprayer scheduled by the test protocols. The results of the above checks and the relevant evaluations are also registered in the same form. If, at the end of Phase B, one or more than one parameter do not fall within the expected acceptability range, a special form has to be filled in and the farmer in question is invited to carry out the necessary repairs. The transition to the Phase C of calibration of the sprayer is possible only when an additional check points out parameters falling within the range of acceptability, after the requested repairs have been carried out.

**Phase C:** The evaluation of the transverse pattern is carried out using the suitable test-bench. Subsequently, once the travel velocity has been determined, the calculation of the delivered volume of distribution is made.

**Phase D:** Delivery of a final report to the farmer together with the sticker.

**References**


The analysis system for inspection of sprayers introduced in Lithuania

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Summary

The legal act on inspection of sprayers in use and certification of new and reconstructed sprayers in Lithuania introduced in 2001. Practically the real work on inspection and certification of sprayers started only in the end of September 2003 due to lack material recourses implementation difficulties. Nowadays the system of inspection and certification of sprayers is under implementation and still faces many problems.

- Sprayers in use – sprayers being used now and in past;
- New sprayers – newly produced sprayers presented on market for sale and use;
- Reconstructed sprayers – new sprayers and sprayers in use which have been reconstructed (modified) in general;
- Inspection of sprayers in use – test of sprayers using methodology according to EN 13790 : 2000 standard;

1. Introduction

According to the legal acts in force LAW ON THE AMENDMENT OF THE LAW ON PLANT PROTECTION (14 October 2003, No. IX-1761, Vilnius) “2. …Plant protection products for professional use must be applied by certified equipment”.

The procedures of inspection and certification of field sprayers are set in THE REGULATIONS FOR THE CONTROL OF SPRAYERS (Regulations) approved by order of the Minister of the Republic of Lithuania on 19 June 2001 No 199. It states “16. It is prohibited to use tractor mounted, 3-point hitch, trailed and self propelled boom sprayers also air assisted crop sprayers without technical inspection certificate and if their construction or functioning do not fulfill the requirements”.

The Regulations in general are prepared according to EN 907 1998 and ISO 5682 1997 standards concerning certification of new and modified sprayers and EN 13790 2000 standard concerning sprayers in use.

2. Inspection procedures and situation

2.1 General requirements and responsible bodies

Regulations for the control of sprayers are applied for tractor-drawn, suspended or hung up, put on and self-propelled pipe and ventilator sprayers. Regulations are compulsory for all physical and legal persons, who trade and use sprayers.

According to the Regulations for the control of sprayers:

- Only sprayers having sprayer certificates of a defined specimen (hereinafter referred to as Certificates) shall be sold and used;
- Certificates shall be valid 3 years from the authorization or extension day;
- The expenses of the new sprayers technical examination shall be paid by manufacturers or sellers;
• The expenses of technical testing of reconstructed and used sprayers – by their owners according to the established procedure;
• For new and reconstructed sprayers which correspond to technical requirements of these regulations the National Machinery Testing Station shall authorize, extend and register certificates and shall give exceptions of technical testing to imported sprayers;
• The Lithuanian Agriculture Engineering Institute methodically shall control the used sprayers technical examination and prepare required recommendations;
• Technical examinations of sprayers already in use shall be organized and carried out, certificates shall be given out or extended by authorized engineers-inspectors of agriculture technology national control of regional agriculture departments or official or officially recognized institutions in accordance with the requirements of these Regulations;
• The national plant protection inspectors shall control if owners shall keep the requirements of these regulations.

2.2 Situation

Actual inspection of sprayers already in use started at the end of August 2003 by authorized engineers-inspectors. Lithuania is divided into 10 administrative zones and 44 district areas. There are 10 engineers-inspectors in Lithuania – one per each administrative zone to make inspections on sprayers in use. Each engineer-inspector are supplied with mobile sprayer inspection kit.

Mobile sprayer inspection kit include instruments to perform very simple measurements:
• Output from each nozzle (liquid measurement cup and debit meter);
• Spraying pressure equity (standard manometer);
• Measurement tape (spraying boom distance to the ground, distance between nozzles, etc.);
• Angle meter (nozzles angles towards sprayer boom);
• Timer;
• Individual protection items.

All other parameters on sprayer are inspected visually.

At the moment in Lithuania working about 8000 sprayers aged:
• Up to 3 years – 14 %,
• From 3 to 5 years – 18 %,
• 5 years and over – 68 %.

About 80 % of sprayers are poor quality (or condition). Most popular sprayers (around 72 %) are 400-600 l. tank volume and 10-12 m. wide.

According to approximate data (end of June 2004) – around 150 sprayers are inspected. Main faults found during inspections on sprayers are:
• Allowed spraying distribution variation coefficient across the boom is acceded;
• Worn out sprayer nozzles;
• Worn out pump;
• Wrong manometer;
• Faults on sprayer boom sections flow distribution controller;
• Sprayer boom is damaged (bends in vertical and horizontal directions).

Information on training:
In different regions of Lithuania at the moment are performed number of trainings for farmers about the preparation for inspection of sprayers;

Around 1200 farmers and agricultural cooperatives stuff are trained up to now;

In the end of training the certificates are awarded.

Main problems on inspection of sprayers:

- Lack of material recourses for additional stuff, inspection equipment, transportation, training and etc.:
- Mobile sprayer inspection kit (to inspect sprayers in use) is suited only for narrow spectrum of tests (inspection quality is poor);
- Quality assurance system isn’t foreseen.

### 3. Conclusions

Nowadays the system of inspection and certification of sprayers in Lithuania is under implementation and faces many problems and challenges for future modernization. In progress to uniform sprayer inspection procedures in Europe legal document has to be developed in close cooperation between concerned European countries.
Are vertical spray patterns an efficient instrument that can improve the adjustment of air-assisted sprayers in vineyard?

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Summary

A specific research was carried out in Italy, involving seven different Institutes around the country, in order to investigate the usefulness of the vertical test benches for the optimisation of spray application in vineyards. Different types of vertical patternators were used (with trays, lamellae, sponges) in order to assess the spray profiles for the single vineyard situations. A first part of the studies, carried out in laboratory, was aimed at assessing the efficiency of the different types of vertical patternators in collecting the liquid sprayed. Field tests were made, in a first phase, to verify the correlation between the spray profile obtained on the patternator and that detected on the vegetation and then to optimise the spray distribution on the target using the vertical patternators as tools. Experimental results pointed out that the different test benches examined are able to produce quite similar profiles and that, at least in the vineyards featured by a uniform development of the vegetation, they are useful to correctly calibrate the sprayers.

1. Introduction

In the ambit of sprayer inspection, a key point is to assess the spray distribution profile in order to optimise the application in the field. If this aspect is relatively simple when testing field crop sprayers, as it is sufficient to evaluate the evenness of the spray pattern by means of an horizontal patternator positioned under the boom, some difficulties arise when air-assisted sprayers for vineyard/orchard have to be inspected. The measurement of the vertical spray profile generated by this type of machines, in fact, requires the use of adequate test benches, featured by a high level of spray retention, and still it is not always considered to be representative of the real spray distribution on vegetation (Pergher et al. 1994; Schmidt and Koch 1995).

With the aim to deeper investigate the usefulness of the assessment of vertical spray patterns in order to improve the adjustment of air-assisted sprayers in vineyards, a research funded by the Italian Ministry of University and Scientific Research was carried out between 1999 and 2001 by seven research teams from seven Universities around the country (Torino, Udine, Bologna, Firenze, Bari, Reggio Calabria and Catania).

The work was structured in three main phases:

1. Evaluation of the efficiency in spray collection performances from different types of vertical patternators.
2. Study of the correlation between the vertical spray profile detected on the test bench and the spray deposition profiles on the vegetation.
3. Assessment of the quality of spray distribution on vegetation when adopting optimised spray profiles obtained using the vertical test benches in comparison with the application of “conventional” spray profiles.
4. In this paper the main results obtained in the experimental tests are presented.
2. Materials and methods

2.1 Tests on different types of vertical patternators

In laboratory, tests aimed at assessing the efficiency of spray collection were carried out using five different types of vertical patternators (Fig. 1): A) test bench fitted with horizontal lamellae; B) test bench provided with vertical lamellae; C) test bench equipped with square trays (size 20x20 cm); D) test bench fitted with inclined trays (size 20x45 cm); E) test bench equipped with slim sponges (20x20 cm). For all the patternators examined, which were positioned at 1.25 m distance from the centre of the sprayer, the percentage of liquid sprayed by the machine collected on the test bench, the repeatability of results in the same spray conditions and the spray distribution profile expressed, for each sampling height, in terms of percentage of the total amount of liquid collected on the patternator were assessed.

![Figure 1: Types of vertical test benches employed in the tests (see text for details).](image)

Tests were made using a conventional air-assisted sprayer equipped with an axial fan (Ø 650 mm) and fitted with 4 hollow cone nozzles on each side of the machine. Two different nozzle sizes (ATR lilac working at 10 bar pressure and ATR blue working at 5 bar pressure) and two different fan rotation speeds (1400 and 2250 rev/min) were combined in order to work with four sprayer configurations.

Spray profiles were detected separately for the three spray sections (high, medium and low) of the machine, obtained activating just two of the four nozzles available, fig. 2. The complete vertical profile was determined making the sum of the low and high spray sections.

For each sprayer configuration and spray section, four replications of the spray profile measurement were carried out.
Patternators A and B operated in static conditions, while test benches C, D and E were mounted on a rail fitted with an electric motor and passed alternatively forward and backward in front of the sprayer.

2.2 Correlation between the vertical spray pattern and the spray deposition on vegetation

Each research team involved in the project worked with a conventional air-assisted sprayer fitted with an axial fan and nozzles mounted on semi-circular booms. Three different vertical spray profiles were selected for the tests, fig. 3. In order to obtain the different spray patterns, the configuration of the sprayer (number and orientation of active nozzles, nozzle size, etc.) was changed.

Figure 2: Scheme of the sprayer set up in front of the vertical test bench for the lab tests.

Figure 3: Example of different spray profiles assessed with the test bench A (square trays).
The same spray profiles obtained on the test bench were adopted for applying on different vine canopies, table 1, a test liquid added with a tracer. Leaf samples collected at different canopy heights, either on the side adjacent to the sprayer pass or on the opposite side, were then analysed by spectrophotometry in order to determine the distribution profile on the vegetation. Spray applications in vineyard were carried out at two different growth stages, featured by different amounts of leaf surfaces. Spray deposits measured on the leaves (µl/cm² of leaf surface) were compared with those assessed on the patternator at the corresponding heights, also expressed in terms of µl per cm² of collecting surface. The coefficient of correlation $r$ between deposits on patternator ($x_1$) and on vegetation ($x_2$) was then calculated for each spray profile examined.

### Table 1: Vineyard parameters related to field tests.

<table>
<thead>
<tr>
<th>Test station</th>
<th>Vine training system</th>
<th>Inter-row (m)</th>
<th>Growth stages (BBCH)</th>
<th>LAI</th>
<th>Volume (l/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torino</td>
<td>Guyot</td>
<td>2.8</td>
<td>Fruit set (71)</td>
<td>0.4</td>
<td>310</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Berries developing colour (83)</td>
<td>1.3</td>
<td>310</td>
</tr>
<tr>
<td>Udine</td>
<td>Casarsa</td>
<td>3.0</td>
<td>Inflorescence emerge (57)</td>
<td>0.5</td>
<td>540</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fruit set (71)</td>
<td>1.3</td>
<td>840</td>
</tr>
<tr>
<td>Firenze</td>
<td>Spur cordon</td>
<td>1.8</td>
<td>Fruit set (71)</td>
<td>2.0</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Development of fruits (75)</td>
<td>3.1</td>
<td>250</td>
</tr>
<tr>
<td>Bari</td>
<td>Tendone</td>
<td>2.3</td>
<td>Full flowering (65)</td>
<td>1.5</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ripening of berries (85)</td>
<td>3.2</td>
<td>600</td>
</tr>
<tr>
<td>Catania</td>
<td>Spur cordon</td>
<td>2.0</td>
<td>Fruit set (71)</td>
<td>1.3</td>
<td>1680</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ripening of berries (85)</td>
<td>1.9</td>
<td>2120</td>
</tr>
<tr>
<td>Reggio</td>
<td>Alberello</td>
<td>2.0</td>
<td>Fruit set (71)</td>
<td>1.8</td>
<td>1170</td>
</tr>
<tr>
<td>Calabria</td>
<td></td>
<td></td>
<td>Development of fruits (75)</td>
<td>1.9</td>
<td>1500</td>
</tr>
</tbody>
</table>

#### 2.3 Quality of spray distribution in vineyard using optimised spray patterns

In the third phase of the research project (2001), the quality of spray distribution in vineyard was assessed comparing the conventional sprayer adjustment, as normally adopted by vine growers on the basis of their own experience in the test sites, with the sprayer set up able to provide an optimised vertical spray pattern on the test bench. Trials were made in the same vineyards where correlation tests were performed, table 1. The guidelines for the optimisation of the spray profiles were mainly based on geometric criteria related to the canopy structure. Rows were divided into three or more bands in height and for each of these bands, the thickness on the horizontal plan and the amount of leaf surface were assessed; the adjustment of the spray pattern therefore aimed at following the so obtained profile of the canopy, in order to provide an amount of spray mixture proportional to the foliage surface in each part of the vine canopy. When comparing the effects of the application of the conventional and of the optimised patterns on vegetation, three parameters were considered: a) the average spray deposit on the leaves; b) the uniformity of spray deposits within the canopy (expressed as coefficient of variation between the figures related to all the leaves samples); c) the index of spray penetration into the canopy, calculated as the ratio between the average spray deposit, assessed on the row side adjacent to the machine, and that found on the opposite side of the row. In order to allow comparisons between applications featured by different volume rates, all data were normalised to a 500 l/ha spray volume.
3. Results

3.1 Tests on different types of vertical patternators

Test results showed that, in general terms, both lamellae (either vertical or horizontal) patternators collected higher amounts of liquid with relative to the other types. Nevertheless the most interesting parameter in order to evaluate the efficiency of each single test bench resulted the difference registered between the percentages of spray collection at the different sampling heights. Test benches B and E presented small differences in the amount of liquid collected between the low, medium and high spray sections, therefore resulted more efficient with respect to the other patternators examined, fig. 4.

Concerning the repeatability of results, for each patternator, coefficients of variation were calculated on the basis of the values obtained in the four replications of each test, table 2. As tests were carried out in laboratory, in stable conditions, a very good evenness of experimental data was found. CV values in fact ranged just from 2 % to 11 %. Lowest CV values were registered for the B patternator (provided with vertical lamellae) when spraying with the ATR lilac nozzles.

Table 2: Coefficient of variation (CV) between the replications of the same test according to the type of test bench and to the spray section activated.

<table>
<thead>
<tr>
<th>Spray section</th>
<th>ATR lilac nozzles</th>
<th>ATR blue nozzles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Horizontal lamellae (A)</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Vertical lamellae (B)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Square trays (C)</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Inclined trays (D)</td>
<td>5</td>
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<td>Sponges (E)</td>
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Concerning the shape of the spray profiles obtained with the different types of vertical patternators and operating with the same sprayer configuration, the best accordance was observed when the ATR blue nozzles, producing relatively coarse droplets (VMD\(^1 = 200 \mu m\)), - in combination with slow fan rotation speed - were employed, fig. 5A. On the other hand, when finer droplets (nozzles ATR lilac, VMD\(^1 = 70 \mu m\)) in combination with the high fan rotation speed were sprayed, the profiles obtained on the five test benches resulted more different one from the other, especially in the band between 0.5 m and 1.5 m sampling height, fig. 5B.

![Figure 5](image_url)

**Figure 5**: Spray profiles obtained using the five different types of test benches working with:
A) ATR lilac nozzles (10 bar) and fan rotation speed of 1400 rev/min;
B) ATR blue nozzles (5 bar) and fan rotation speed of 2250 rev/min.

\(^1\) Measured by means of Malvern instrument.
3.2 Correlation between the vertical spray pattern and the spray deposition on vegetation

All tests carried out by the different research teams showed a positive correlation between the spray deposits on the leaves and those on the patternators, but figures of the coefficient of correlation resulted quite in a wide range, fig. 6, depending on the features of the vineyard treated (layout, height and thickness of the rows, growth stage) and on the position of the leaf samples in the row with respect to the sprayer pass (adjacent side, opposite side). Concerning the latter aspect, the correlation between the deposits on the test bench and on the canopy resulted generally higher when the deposits on the adjacent (near) side of the row were considered.

In the vineyards trained according to the spur-cordon system (Firenze, Catania, table 1) coefficients of correlation close to 1 were obtained, independently of the growth stage, fig. 6.

![Figure 6: Correlation between spray deposits on test benches and on vegetation.](image)

3.3 Quality of spray distribution in vineyard using optimised spray patterns

Considering the overall amount of data registered in the seven test stations, the average normalised spray deposit on the leaves was 0.59 µl/cm² when using optimised spray profiles, while just 0.36 µl/cm² (-39 %) for conventional spray profiles. Also the uniformity of spray distribution within the canopy resulted improved when the optimised spray patterns were applied. The average CV between the spray deposits on the leaves was around 20 % for the tests carried out with optimised profiles, but raised up to 38 % when the conventional sprayer adjustment was used.

Finally, concerning the penetration of the spray mixture into the vegetation, the index values resulted generally higher when the optimised spray profiles were adopted with respect to the conventional spray patterns, fig. 7.
4. Conclusions

Experimental results indicated that the calibration of vineyard sprayers according to the geometric features of the canopies significantly improved the quality of spray application. All of the vertical test benches employed resulted useful as tools to optimise spray application in the vineyard, providing good repeatability of results in the same spraying conditions. The relative comparison between the patternators, however, pointed out some limits in the definition of an equal spray profile when applying very fine droplets and high air velocities.

The vertical spray patterns assessed using the test benches showed a very good correlation with the spray profiles registered on vine rows especially when operating in vineyards trained to the spur cordon system, featured by well developed and homogeneous canopies. When the vineyard presented an uneven development of the vegetation at the different heights of the canopy, the correlation between patternator spray profiles and deposits on the leaves resulted poorer.

Due to the large variety of vine training systems present in Italy, further studies are necessary in order to investigate which spray profiles should be recommended under each specific situation. The availability of a wider regulation range of spray jets and air flows on the sprayers would easier allow to improve the quality of spray application in vineyards.

Acknowledgements

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References


Evaluation of vertical pattern distribution by means of horizontal and vertical lamellae patternators

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Summary

The evaluation of the vertical distribution pattern is a crucial test to achieve a good quality of spray application in orchards. The available patternators are based on different technologies. The aim of this work was to compare the performance of a vertical lamellae patternator versus a horizontal lamellae patternator. For this aim, an experimental device that allows the use of the same patternator, mounting the lamellae either horizontally or vertically, was utilized. The results showed that using the patternator with vertical lamellae a greater amount of liquid was collected than using the horizontal lamellae under the same test conditions. This result is clearer in the height range from 0.67 m to 1.87 m, whereas the collection is very similar in the higher part of the bench. Although the data of liquid collection is not considered the only parameter to assess the quality of a patternator, this characteristic could be very useful especially when low volume orchard sprayers are tested.

1. Introduction

Among the possible sources of environmental contamination by crop protection products, the use of air blast sprayers in orchards and vineyards has been very critical. In the last years during the inspection of sprayers already in use, an important feature of testing in Italy is the estimation of the vertical distribution pattern. This test allows: 1) to direct the spray only on the tree crown, reducing the off-target, 2) to regulate nozzle orientation to achieve an ideal spray pattern and 3) to reduce differences between right and left side distribution in traditional sprayers with an axial fan, a model that is still very common in Italy.

The testing of vertical distribution pattern is generally carried out by means of patternators based on very different technologies (Pessina 2000; Biocca 2001). In some previous tests, significant results were obtained using vertical lamellae patternators (Biocca and Grilli 1999; Biocca and Grilli 2000). These devices have lamellae with a peculiar design capable of collecting sprayed liquid by means of the reduction of air speed. The lamellae can mounted both vertically and horizontally and commercial patternators are available with both systems.

The aim of this work is to compare the performance of a vertical lamellae patternator to a horizontal lamellae patternator.

2. Materials and methods

The commercial devices are very different in shape, material and other characteristics and the evaluation of their performances is not very simple. In order to compare the liquid collection of a vertical patternator based on a commercial bench, an experimental device was utilized in the trials. It consists of a single patternator, mounting the lamellae either horizontally or vertically by means of the rotation of the frame where the patternator is mounted. Then, it is possible to place the patternator at different heights from 170 mm to 3270 mm. The patternator consists of 20 lamellae spacing 2.5 cm. The interception area is 0.09 m².

Each patterntagor was tested for liquid collection performances with different sprayed volumes, placing the patternators at least at five different heights (centre of the patternator: from 0.67 m to 3.07 m, spacing 600 mm). The amount of collected liquid was measured at least three times for each test.

All the trials were carried out using a trailed orchard sprayer (Nobili Geo 75-600 T) spraying the bench only with the right side of the sprayer (6 traditional ceramic nozzles in total) and placing the sprayer at 1.5 m from the bench.
The sprayer was adjusted with the following setups: 1) flow rate “low” (= 19.6 l/min) and 2) flow rate “high” (= 22.5 l/min); the two flow-rates were obtained setting the pressure at 1000 kPa and 1500 kPa. The air velocity of five points in front of the patternator was measured by means of an anemometer Schiltknecht Micro MiniAir 4 (with each measure as an integration of 30 seconds period of measurement).

3. Results

Under the test conditions, the results showed that the vertical lamellae patternators are able to intercept a 28.2 % liquid more than horizontal lamellae (average of total liquid collection in 16 tests in different conditions) (i.e. 13.61 l/ m² of interception area in vertical vs. 9.77 l/ m² in horizontal).

In the figures 1 and 2 the results of liquid collection in the two systems at different heights are shown.

**Figure 1**: Mean of collected liquid +/- s.e. (average of 16 tests).

**Figure 2**: Percentage of liquid collection - (relative values average of 16 tests).
Figure 3: Air speed in front of the patternators at different heights.

The comparison between different spray volumes shows that using the vertical lamellae a similar liquid collection with the two different volumes was collected.

The air speed difference in front of the patternator shows that the vertical lamellae act a minor reduction of air speed than the horizontal lamellae, fig. 3.

4. Conclusions

The results showed that using the patternator with vertical lamellae a greater amount of liquid was collected than using the horizontal lamellae under the same test conditions.

This result is clearer in the height range from 0.67 m to 1.87 m (lower heights), whereas the collection is very similar in the higher part of the bench.

Although the data of liquid collection is not considered the only parameter to assess the quality of a patternator, this characteristic could be very useful especially when low volume orchard sprayers are tested (Ade and Venturi 1995).

The best performance of vertical lamellae in terms of total liquid collection in the lower heights may be explained analysing the air speed behaviour around the patternator. The vertical lamellae can act a less remarkable disturbance of the air, with likely greater liquid collection than horizontal lamellae. However, where the air speed is much lower (i.e. at the higher heights), since the differences in terms of air speed reduction is less remarkable, the two patternators show a similar performance.

References

An overview of the situation in the field of devices used for the application of plant protection products in Slovenia

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Summary

In Slovenia, regular inspections of devices used for the application of plant protection products (PPP) have been carried out, with certain interruptions, since 1975; however, they were not enforced by law. In 1994, a Law on Sanitary Protection of Plants (Official Gazette of the Republic of Slovenia, No. 82/94) was passed regulating and unifying the procedures used at testing of PPP application devices. It also prescribed that regular inspections had to be performed every third year and every year for the organisations and persons taking measures of plant protection for other persons. In 2001, a new Law on Plant Protection Products (Official Gazette of the Republic of Slovenia, No. 11/01) was passed. Its Paragraph No. 47 provides that owners of devices had to acquire a symbol of regular inspection every two years. The symbol of regular inspection can be acquired only by certified devices. The Rule Book on Acquisition of Harmonisation Certificate for Application Devices of Plant Protection Products (Official Gazette of the Republic of Slovenia, No. 37/01) provides technical requirements, conditions and procedures for the acquisition of certificate. In Slovenia, this type of devices is certified by Biotechnical Faculty in Ljubljana and Agricultural Faculty in Maribor which have issued 126 certificates in the period from 2000 to 2004. Regular inspections of PPP application devices are carried out by nine organisations authorised by Ministry of Agriculture, Forestry and Food which have been using a computer system since 1996, however, with a relatively out-of-date testing equipment, especially in case of testing of mistblowers. In the period from 1994 to 2001, 1127 devices were tested on the average annually, and from 2001 to 2004 the number amounted to 2591, which is approximately 5 % of all devices owned by those taking plant protection measures in Slovenia. Consequently, in the future an essentially greater attention will have to be paid to activities which will contribute to a more vast response of users to the regular testing of devices.

1. Introduction

In Slovenia, with its legislation in the field of agriculture, i.e. its Law on Agriculture (Official Gazette of the Republic of Slovenia, No. 54/00, 52/00 and 58/02), among the goals of its agricultural policy, special attention is paid to protection of agricultural land from pollution and aimless use as well as to materialisation of principles of environmental protection and preservation of nature. The law deals with the economic, physical, ecological and social role of agriculture and lays down the principle of agricultural policy measures which ought to be directed towards the stimulation of such a sustainable agricultural activity to maintain the diversity of animal and plant species and preserve the soil and its fertility along with the protection of natural conditions required for the life in soil, water and air. Protection of plants from various diseases and pests is vital for a yield of high quantity and quality. Nowadays, plants are protected from diseases and various harmful organisms primarily with chemical products found in various forms. A tendency has been noticed towards decreasing their use by a more precise application onto plants and restriction of their use by sowing of more resistant plant varieties, by using biological and biotechnological methods and by introduction of parasites to lessen the extent of plant infection by completely or partially destroying the pests and agents of diseases. The use of chemical products for plant protection has to be harmonised with the degree of sanitary endangerment of plants or weediness of crop by taking into consideration also the present and the forecasted weather and soil conditions (Mrhar 1997). Thus it is the application of these products that has been gaining importance, which means that the products have to be applied in an adequate dose or concentration in (on) soil and on plants to reach such a coating and distribution of active substance to ensure the optimal effect against harmful organisms. We have to be aware that up-to-date plant protection products are...
optimally efficient only if their application on plants and in (on) soil, i.e. their mechanical application, is as developed as possible (Maček and Novak 1990).

The basic objective of the application technique, i.e. a purposeful, economical and environmental friendly application of adequately prepared chemical products on target surfaces, means at the same time a certain intervention in the environment. If we want to use them efficiently and safely we have to know a lot about them as well as about the application devices since their quality and handling allow a better efficiency of chemical products and lesser introduction of unwanted substances in the environment. The use of machines of which we do not know their working characteristics or which are not legally defined may be very dangerous. Regular inspections of machines and devices ensure their proper maintenance. High degree of awareness, education and prompt information of users with novelties in this field are a vital prerequisite for a safe use of these devices.

According to the Law on Sanitary Plant Protection (ZVR-1, Official Gazette of the Republic of Slovenia, No. 45/01), sanitary protection of plants means the protection of health of plants, plant products and controlled objects from harmful organisms using the plant protection measures. The field of trade and use of plant protection products is regulated by Law on Plant Protection Products (ZFTS, Official Gazette of the Republic of Slovenia, No. 11/01) which forbids the release and use of plant protection products unless they had been registered at the proper governmental agency. Their use requires the consideration of the principles of a sound agricultural practice and integrated plant protection by not endangering the health of people and animals and by not exerting a negative influence on the environment. The Law mentioned above sums up the European legislation in this field implementing the system of registration, trade, use and inspection of plant protection products in a similar way as that of the European Union. It also prescribes additional training of all those coming into contact with plant protection products in agriculture while more detailed conditions are given in the Rules on Technical Training and Content and Way of Passing the Phytomedicine Examination and Test of Knowledge on Plant Protection (Official Gazette of the Republic of Slovenia, No. 12/00). In Slovenia, only those devices may be released which ensure an application of plant protection products that is not harmful to people and environment, which have acquired a certificate on harmonisation, and fulfil the conditions stipulated in the certificate. The Rules on Acquisition of Certificate on Harmonisation for Application Devices of Plant Protection Products (official Gazette of the Republic of Slovenia, No. 37/01, 80/01 and 117/02) define the type of devices which have to acquire certificate on harmonisation before they are released. The devices are certified by two bodies: Biotechnical Faculty in Ljubljana and Faculty of Agriculture in Maribor. The owners of devices may use only regularly inspected devices owning a symbol of regular inspection. The latter, which the owners of the devices have to acquire every two years, is issued by legal or natural person who is by a provision on administrative procedure authorised by a competent body if it fulfils the conditions regarding the premises, equipment and personnel. More detailed stipulations are contained in the rules on conditions and procedures which have to be fulfilled by authorised inspection bodies for regular inspection of devices used for the application of plant protection products (Official Gazette of the Republic of Slovenia, No. 12/00). Regular inspections of devices used for the application of plant protection products in the territory of Slovenia are carried out by nine organisations: Faculty of Agriculture Maribor, Biotechnical Faculty Ljubljana, Secondary Dairy and Agricultural School Kranj, Secondary Agricultural School Grm Novo mesto, Educational Centre Ptuj – Vocational and Technical Agricultural School, Agricultural and Household School Šentjur, Educational Centre Nova Gorica – Vocational and Technical Agricultural Food Processing School and Slovenian Institute for Hop Research and Brewery.

2. Materials and methods

2.1 Field testing of devices for the application of plant protection products

In Slovenia, regular inspections of devices used for the application of plant protection products have been carried out since 1975. Testing teams have been using a computer system at their work since 1996 which had been developed to cover the needs of field testing; however, the testing equipment they use is rather obsolete, for instance the classical Spray Scanner. Only two testing teams use up to date electronic Spray Scanner. The situation is much worse with the equipment for testing mistblowers, since no team has a Spray Scanner for vertical distribution at its disposal. Special problem in the testing of this kind of devices in Slovenia lies in the fact that 95 % of all the devices are inspected in the field. Each testing
team inspects the devices on an average of 23 different locations of its territory. In the period of legally binding testing of devices, from 1994 to 2001 there were 1127 devices inspected on the average per year and 2591 from 2001 to 2004. The number of devices inspected by individual testing teams is presented in table 1.

Table 1: Total number of devices inspected in particular years in Slovenia.

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Figure 1: Total number of devices inspected in the period from 1994 to 2004.

2.2 Certification of devices

The symbol of regular inspection of devices may be obtained only by certified devices. The Rule Book on Acquisition of Harmonisation Certificate for Application Devices of Plant Protection Products (Official Gazette of the Republic of Slovenia, No. 37/01) provides technical requirements, conditions and procedures for the acquisition of certificate. In Slovenia, these devices are certified by Biotechnical Faculty in Ljubljana and Faculty of Agriculture in Maribor which issued 126 certificates in the period from 2000 to 2004.
3. Conclusions

In the field of devices used for the application of plant protection products the spraying technique is rather obsolete since the spraying devices are more than 18 years old on the average. They are 95% manufactured by national firms Agromehanika Kranj and Metalna Maribor. Due to the small size of Slovene farms the devices with 300 l tank volume and 8 m working width prevail but they do not have any additional tanks for washing and cleaning of hands. In the period from 2001 to 2003 a trend of increased number of testing devices was noticed which may be attributed to a more severe legislation and surveillance in this field. The priority of inspection bodies for testing of spraying devices is a modernisation of testing equipment and building of stationary centres for the inspection of devices used for the application of plant protection products.

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Zakon o fitofarmacevtskih sredstvih, Ur. 1. RS, št. 11/01.
Zakon o zdravstvenem varstvu rastlin, Ur. 1. RS, št. 45/01.
Results Session 3 - Technical prerequisites required for conducting on inspections

1. Current situation in the Member States (MS) and candidate countries (CC)
   1. Testing equipment and other testing facilities are generally not in accordance with EN 13790.
   2. Different technical systems are used for inspection of air-assisted sprayers for bush and tree crops (vertical distribution measurement).

2. Objectives to improve the current situation
   - Observance of (new) administrative regulations.

3. Need for further action – short-/long-term
   1. Establish a list of technical prerequisites for implementing an inspection. Establish a sort of „step by step receipt“ and focus on the key points of the success.
   2. Define inspection procedures for brand new sprayers.
   3. Define how to manage sprayers with minor defaults.
   4. Follow the definitions of EN 13790 concerning vertical distribution measurements for air-assisted sprayers.
   5. Ensure the repeatability and the reproducibility of the measurements by agreed protocols.
   6. Specify the procedure of approving the measuring instrumentation.

Examine the possibility for a European research project on measurement technology for vertical distribution of sprayers.
Session 4 - Quality management for inspections

Technical requirements set by different standards when performing accredited inspections

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**Summary**
In recent years more and more obligations in connection with registration and traceability in the production process have been imposed on food producers (e.g. EUREP-GAP). Quality requirements are also imposed upon the farmers with the compulsory inspection of their sprayers. It is evident that the inspection service should guarantee that the inspection is carried out correctly, accurately, in an objective and repeatable way. This can be done by accrediting the inspection services according to the European Standard EN 45004:1995 'General criteria for the operation of various types of bodies performing inspection'. This standard describes in detail an extensive list of requirements and conditions that must be satisfied by an inspection service before it can be accredited according to this standard. All member countries of the EU and many other European countries have accepted this standard. The demand that all test results can be reduced to national or international standards is one of the most important requirements enforced by EN 45004. Until recently, only the standard ISO 5682-2:1997 'Test methods for hydraulic sprayers' was available and complied with this requirement. Now, with EN 13790-1 and 2:2002 'Agricultural machinery - Sprayers - Inspection of sprayers in use', a specific standard concerning how inspections should be done, is available. There are quite some differences between these two standards. Particularly, the ways to guarantee correct measuring results are different. ISO 5682-2 defines a number of required accuracies for several measuring devices, while EN 13790-1 and 2 mentions maximal allowed errors for some measuring devices. Nevertheless, an inspection service that wishes to accredit its activities should analyse carefully which standard it chooses to comply with. Parameters that should be taken into account are: national inspection procedures, measuring devices used, way of organisation of inspections, etc.

1. **Introduction**

In recent years more and more (administrative) obligations in connection with registration and traceability in the production process have been imposed on food producers. These obligations can be the result of an initiative of the supermarket chains (e.g. EUREP-GAP) but can also be imposed by the authorities for example because of a number of food crises and outbreaks of very contagious animal diseases. These additional obligations for farmers and horticulturists, which from the point of view of food safety must be strictly met and are fully justifiable, encounter some opposition in the present difficult economic context within the European agriculture and horticulture.

Quality requirements are also imposed upon the farmers with the compulsory inspection of their sprayers. It is evident that the inspection service should guarantee that the inspection is carried out correctly, accurately, in an objective and repeatable way. The most demanding way to do this is to accredit the general inspection service and/or the individual test centres according to the European Standard EN 45004.

This standard describes in detail an extensive list of requirements and conditions that must be fulfilled by an inspection service before it can be accredited according to this standard. All member countries of the EU and many other European countries have accepted this standard.

The accreditation is a guarantee for objective and correct measurements, a guarantee that all measurements are executed according to the highest quality standards described by EN or ISO.
2. Quality management

2.1 Certification or accreditation?

There are several possibilities to guarantee the quality of the inspections and the control on inspection workshops. One could opt for a simple control system without any certification or accreditation. This kind of basic quality management should include an analysis of possible problems and a registration and documentation of the most important activities and measurements. The advantages of such a system are: simple, low costs, easy to build up step by step. Actually, this kind of quality management should already be part of any good functioning inspection workshop and control service.

A step further is a certification according to e.g. ISO 9002:1994 Quality systems - Model for quality assurance in production, installation and servicing. This standard describes the requirements with which a quality system should comply to guarantee that all customer demands are realised. A certification according to ISO 9002 proves that you are working according to a certain quality system, but it is not a safeguard for the achieved inspection results because the standard does not enforce any technical requirements! A more uniform functioning and the possibility to compare different quality systems could be regarded as two important advantages of a certification. Most important disadvantages are the expanded administration and the fact that no technical requirements are enforced through the certification.

Administrative and technical requirements are enforced through an accreditation according to EN 45004:1995 'General criteria for the operation of various types of bodies performing inspection'. It is very clear that those requirements do not only concern the management, like it is the case for ISO 9002. They go beyond that and also concern the technical competence of the inspection service. Contrary to ISO 9002, EN 45004 will impose stringent technical criteria on, for instance: the scientific suitability of the applied methods. That is why the accreditation of an inspection body according to EN 45004 is a guarantee for the reliability of analytical results whereas a certification according to ISO 9002 cannot give this guarantee.

At this moment the Inspection Service of Sprayers in Flanders, Belgium is, to our knowledge, the sole inspection service worldwide in the field of spraying techniques that was able to obtain an accreditation according to EN 45004.

The implementation of a quality system according to EN 45004 certainly brings about a larger administration. Although this is often seen as an important disadvantage, it is a necessity: registration and classification of all results of calibration, maintenance and measurements assure the highest possible traceability of the inspections. The higher frequency of validation and calibration clearly results in higher costs for maintenance, repair and a higher replacement frequency of measuring devices. On the other hand, the risk of performing inspections with inaccurate measuring devices is strongly reduced. Since the start of the implementation of the quality system, the management could clearly see an increasing commitment of the inspectors towards the quality of their work.

2.2 ISO 5682 - 2 versus EN 13790 - 1 and 2

The demand that all test results can be reduced to national or international standards is one of the most important requirements enforced by EN 45004. Until recently, only the standard ISO 5682-2:1997 'Test methods for hydraulic sprayers' was available and complied with this requirement. Now, with EN 13790-1 and 2 : 2002 'Agricultural machinery - Sprayers - Inspection of sprayers in use', a second specific standard is available, concerning how inspections should be carried out. There are quite some differences between the two standards. Particularly, the ways to guarantee correct measuring results are different. ISO 5682-2 defines a number of required accuracies for several measuring devices, where EN 13790 - 1 and 2 mentions maximal allowed errors for some measuring devices. Except for the pressure gauges, 13790-1 and 2 specifies required accuracies. Both are summarized in table 1.
Table 1: Required accuracies of measurements described in ISO 5682-2 and maximal allowed errors according to EN 13790-1 and 2.

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<td>Pressure</td>
<td>Table 1. EN 13790-1 and 2</td>
<td>± 2.5 %</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Angle</td>
<td>/</td>
<td>± 1°</td>
</tr>
<tr>
<td>Distance</td>
<td>/</td>
<td>± 1 mm</td>
</tr>
<tr>
<td>Temperature</td>
<td>/</td>
<td>± 0.5 °C</td>
</tr>
<tr>
<td>Flow rate pump (flow meter)</td>
<td>2 % of m.v.* (≥100 l/min)</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>2 l/min (&lt; 100 l/min)</td>
<td>/</td>
</tr>
<tr>
<td>Flow rate nozzles</td>
<td>≤ 2,5 % of m.v.*</td>
<td>/</td>
</tr>
<tr>
<td>Spray volume (flow meter)</td>
<td>≤ 1,5 % of m.v.*</td>
<td>/</td>
</tr>
</tbody>
</table>

* m.v. = measured value

It appears that the used terminology on accuracy and error was not used correctly (consistently) in these standards. In research ‘accuracy’ is usually interpreted as a property directly linked to the measuring instrument whereas ‘error’ is sooner linked to the measuring result or the measuring methodology. According to this reasoning, ‘error’ in the standard EN 13790-1 and 2 should be interpreted as ‘accuracy’. A clear definition of both terms should be stated at the introduction of the standards.

Only for pressure measurements both standards clearly require an accuracy. Table 2 compares these requirements for some test values. The presentation of the accuracies mentioned in 13790-1 and 2 allows different interpretations: they should be used as an absolute interval or as boundaries of an uniform interval including the test value?

Table 2: Comparison of the technical requirements of pressure gauges according to ISO 5682-2 and EN 13790-1 and 2

<table>
<thead>
<tr>
<th>Test value (bar)</th>
<th>5682-2</th>
<th>13790-1 and 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>± 50 gr [100 gr]</td>
<td>± 100 gr or [100 gr]</td>
</tr>
<tr>
<td>4</td>
<td>± 100 gr [200 gr]</td>
<td>± 100 gr or [100 gr]</td>
</tr>
<tr>
<td>6</td>
<td>± 150 gr [300 gr]</td>
<td>± 100 gr or [100 gr]</td>
</tr>
<tr>
<td>12</td>
<td>± 300 gr [600 gr]</td>
<td>± 250 gr or [250 gr]</td>
</tr>
<tr>
<td>16</td>
<td>± 400 gr [800 gr]</td>
<td>± 250 gr or [250 gr]</td>
</tr>
<tr>
<td>20</td>
<td>± 500 gr [1000 gr]</td>
<td>± 1000 gr or [1000 gr]</td>
</tr>
</tbody>
</table>

According to EN 837-1 1997 'Pressure gauges - Part 1: Bourdon tube pressure gauges - Dimensions, metrology, requirements and testing' the defined accuracies should be used to set the boundaries (+ and -) of the maximum permissible error!

ISO 5682-2 also contains requirements for temperature and relative humidity, whereas for EN 13790-1 and 2 this is not the case

3. Discussion

Before comparing the two standards on what their technical requirements, one can wonder if there is a common basis to do this? Looking at the scopes of the two standards it is clear that both standards try to achieve the same outline: the evaluation of the performance of sprayers. The scope of ISO 5682-2 states that it 'specifies the methods of testing and assessing the performance and accuracy of distribution of hydraulic sprayers for field crops'. Focussing on this scope, one could conclude that this standard is only treating the measurement of the liquid distribution, despite the fact that ISO 5682-2 contains also
requirements on how to evaluate the flow rates of nozzles, the spacing of the nozzles, the discharge from
the pump, the tank filling device, the tank capacity and the agitation. The scope of EN 13790-1 and 2 is
described as specified the requirements and methods of their verification for the inspection of field crop
sprayers (Part 1) and air-assisted sprayers for bush and tree crops (Part 2) in use. The number of sprayer
parts for which requirements are included in this standard are far more elaborate! EN 13790-1 and 2
describes test methods and tolerances for power transmission parts, the pump, the agitation, the spray
liquid tank, the measuring systems, controls and regulation systems, pipes and hoses, filtering, the spray
boom, nozzles, the (transverse) distribution and the blower (air-assisted sprayers). In this way, EN 13790
- 1 and 2, is far more elaborated and can really be regarded as a kind of technical manual on how to
perform inspections of sprayers.

The requirements in the standard ISO 5682-2 for temperature and relative humidity clearly complicate
the organisation of inspections when this standard is used as a technical basis. In practice, these
requirements are impossible to comply with for inspection workshops. On the other hand, this standard
contains required accuracies for a higher number of basic unit.

According to this reading, one could suggest that the standard EN 13790 - 1 and 2 is an excellent
technical basis to perform accredited inspections according to EN 45004 if some matters are explained. It
is clear that EN 13790-1 and 2 is more elaborated what the proposed test methods and tolerances for the
different sprayer parts concerns, but the ways to guarantee correct measuring results (interpretation 'error'
<> 'accuracy' and the required accuracies for pressure gauges) need clarification. When this is the case,
the Inspection Service in Flanders, Belgian will use the standard EN 13790-1 and 2 2002 'Agricultural
machinery - Sprayers - Inspection of sprayers in use' as a technical basis for their accredited inspections.

References
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sprayers and Part 2: Air-assisted sprayers for bush and tree crops, 16 pp.
CEN, EN 837-1:1997. Pressure gauges - Part 1: Bourdon tube pressure gauges - Dimensions, metrology, requirements
and testing, 39 pp. Belgian Institute for Normalisation, Brussels (BIN).
Assuring the measurement precision of testing devices for the control of plant protection devices in different states of Germany

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Summary
In Germany, as well as in other countries, the variation of different sprayer types is really high. There are field sprayers, orchard sprayers and numerous special sprayer devices for crops like asparagus, christmas trees, cherry standard trees and under-leaf and band sprayer devices for corn and sugar beets as well. In Bavaria for example, 5000 air-assisted sprayers are working in different ambient cultures (hop-growing, viticulture and fruit growing).

1. Introduction
In Germany nearly all sprayer types have to be examined by “officially authorized inspection workshops” in a two-years rotation. Plenty of inspection devices are at different controlling-sites throughout country. The control comprises the test of pressure gauges, pump performance and flow-meters as well as the measurement of the cross distribution (CV) for field sprayers and for measurement of single nozzle output for atomizers and special sprayer devices.

2. Different organisation in the states of Germany
The operators of the mentioned measuring equipments are obliged by federal state ordinance to have the measuring precision being tested by an expert before the first use (for new acquisitions) or after repairs and every second year as well. The way of testing the equipment is different in every single state. For instance in Bavaria the personnel of DEULA test engineering carries exclusively out the inspection of test units. DEULA is also capable of carrying-out re-adjustments of the test units on-site in the controlling enterprises.

Figure 1: Testing of BayWa test units by DEULA on site.

In North-Rhine Westfalia (NRW) and Lower Saxony the chamber of agriculture is the control authority which is responsible for the perfect function of the test equipment. In NRW the control workshops has to bring their test facilities to a central place, the head office of the chamber of agriculture, for inspection
and quality control. In the Lower Saxony a test team is carrying out the testing on-site in the controlling workshops.

**Figure 2**: Stationary testing of workshop equipment at the head quarter of the chamber of agriculture in North Rhine Westphalia.

If the measurement precision is suitable, the inspection technique receives a badge with the duration of inspection validity.

**Figure 3**: badge “Kalibriert” that shows the duration of inspection validity. In this case next inspection in April 2006.

The inspection of the testing units comprises in detail the following parts:

- the pressure gauge with a hydraulic/electric testing-unit,
- the flow-meter by means of a vane wheel impeller,
- the cross distribution test stands for the strict keeping to the driving-distance covered,
- the measured water quantity,
- the single nozzle measuring devices for measurement precision of a water quantity exactly allocated with a laboratory measuring cylinder,
• the single nozzle measuring devices for measurement precision of a water quantity exactly allocated with a laboratory measuring cylinder.

![Figure 4: testing the pressure gauge with electronical device.](image1)

![Figure 5: inspection unit to measure the pump performance and flow meter (on site testing in Bavaria).](image2)

The all out testing of the equipment of the testing companies is necessary, so that it is assured that plant protection devices are examined with exactly measuring devices. The testing personal of the testing companies as well is trained by the responsible agricultural department. So that the owners of sprayers can assume, that costs of repair at their sprayer do not arise by false measurement results. This creates a relationship of confidence between testing enterprise and implement owner.
Quality control of testing stations and tested sprayers

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Summary

In the Netherlands the SKL organises and controls the compulsory tests of field and air-assisted sprayers. A network of SKL approved testing stations performs the tests. A quality control system is necessary in order to get uniform tests on a high quality level. In order to assure the quality, controls on three levels are necessary: administrative, inspection of the testing stations and inspections on the performed tests. SKL’s quality control system is certified under ISO 9001 : 2000, which guarantees a continuing improvement of the system. In order to get a meaningful system, a sanction regime is necessary.

1. Introduction

The purpose of a sprayer inspection system is that the machines in all their diversity will be inspected in a uniform way. To certify this, a system of quality assurance and quality control is necessary. There are two ways of organising the sprayer inspections, a central organised system and a de-central organised system. In the Netherlands is chosen for a de-central organisation where a central body organise the inspections and the tests themselves are carried out by approved testing stations. The base for uniformity are a clear set of standards for testing the sprayers, the standard has to stay state-of-the-art to cover all technical innovations. For the execution of the inspections there must be a clear outline of the requirements the approved testing stations have to meet in order of testing facilities and equipment. Another important part of the chain is that a qualified person carries out the tests. To guarantee the uniformity a quality assurance system is necessary and a control system has to operate. To get some pressure on the test stations a system of sanctions is also needed. In this paper these elements will be treated and focussed on the situation in the Netherlands.

2. History and organisation of the sprayer inspection in the Netherlands

2.1 History

In the Netherlands is some history of sprayer-inspection. In 1988 the Foundation for Quality Control of Agricultural Machinery (SKL) was founded with the purpose to improve the maintenance conditions of field crop sprayers in use in agriculture. SKL formed a network of testing stations, spread over the Netherlands. The first 35 stations were subsidised by the government. In 2004 the number of testing stations for field crop sprayers has grown to 136 and to 12 testing stations for air-assisted sprayers. All farmers have now a testing station within a reasonable distance.

First the tests of the field crop sprayers were voluntary, purchasers of their products, like potatoes and vegetables, stimulated the farmers. Since April 1st, 1997 the testing of the field crop sprayers is compulsory every second year. Testing of air-assisted sprayers was possible on voluntary base since 1995. Six testing stations started with the tests. Growers were stimulated to participate by the purchasers of their products. Since April 1st, 2002 the testing of the air-assisted sprayers is also changed from voluntary into obligatory.

In figure 1 and 2 are the number of inspected field and air-assisted sprayers since 1991.
In 2003 still more than half of the sprayers needed reparations (field crop sprayers 56% and air-assisted sprayers 69%) before approval. In table 1 are the most occurring failures for field crop sprayers and in table 2 for the air-assisted sprayers in 2003.

**Table 1: Main failures field crop sprayers in 2003.**

<table>
<thead>
<tr>
<th>Failure</th>
<th>% of all tested machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaksages of the machine</td>
<td>35.2%</td>
</tr>
<tr>
<td>Bad distribution nozzles</td>
<td>15.0%</td>
</tr>
<tr>
<td>Deficiencies spray-boom</td>
<td>13.0%</td>
</tr>
<tr>
<td>Bended or damaged hoses</td>
<td>12.8%</td>
</tr>
<tr>
<td>Spray liquid tank: level indicator, strainer, cover</td>
<td>12.1%</td>
</tr>
</tbody>
</table>

**Table 2: Main failures air-assisted sprayers in 2003.**

<table>
<thead>
<tr>
<th>Failure</th>
<th>% of all tested machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow rate nozzles exceed standard</td>
<td>40.4%</td>
</tr>
<tr>
<td>Dripping nozzles after the spray has collapsed</td>
<td>38.6%</td>
</tr>
<tr>
<td>Pressure gauge: inaccurate, scale not correct</td>
<td>36.6%</td>
</tr>
<tr>
<td>Bad function control devices</td>
<td>17.2%</td>
</tr>
<tr>
<td>Dangerous or dirty blower</td>
<td>10.2%</td>
</tr>
</tbody>
</table>
2.2 Organisation

The sprayer tests are obligatory by regulations of the Product Boards for Agriculture, Horticulture and Dairy products. These regulations are binding for all farmers and horticulturists. In the regulations are the requirements, which apply to the spraying equipment, and is the SKL appointed as certified body to perform the tests. The SKL has the execution of the test put out to SKL-approved testing stations. SKL puts the requirements at the testing stations and looks after the fulfilment of these requirements. SKL reports periodically to the Product Boards about the number of sprayer tests and results of the inspections.

Private firms like local dealers of agricultural machinery, who have a contract with SKL, own the testing stations. SKL provides testing contracts, testing forms, approval stickers and performs inspection of the stations and of the tested sprayers.

A yearly fee from the testing stations to the SKL and the price of an approval sticker finance the system. The test fee the owner of the sprayer has to pay to the testing station is left to the market and depends on the working width of the sprayer, the number of nozzles, etc. In most cases the price is built up with a fixed component (costs of the approval sticker, fixed costs of the testing station) and a variable part (the time spent with the inspection times the price per hour).

3. Standards, requirements at the test stations and test operators

3.1 Standards for testing the machines

The base of the standards for testing the machines is in the regulations of the Product boards. For the testing stations on base of these standards a manual is made. In this manual is more explanation of the standards, some critical cases are more worked out in order to get more uniformity. SKL has a technical committee in which are representatives of the Product boards, the testing stations, the users (farmers and contractors) and the industry. In this committee new developments are discussed, problems that occur are treated and the committee can give an advise to the Product boards to change the standards.

The actual versions of the manual are in use at the testing stations. In case of minor changes or things that are not clear in the manual, an interpretation file is made. In this file issues what can give discussions are made clear. This file is also spread to all testing stations.

3.2 Requirements at the testing stations

The approved testing stations have to meet requirements for the test facilities, the equipment they have and the test-operator. There are approved stations for testing field-crop sprayers and stations for testing air-assisted sprayers. Some firms have both approvals.

For an approval the matters mentioned below are needed:

**Testing facilities:** A testing station shall perform tests preferably inside a building with the possibility to collect the sprayed water and to dispose of exhaust gasses of the tractor. In case this facility is not available, still the influence of the weather has to be prevented. That means that at least a roof and three wind breaking walls are required.

**Test equipment:** The following equipment is required at the test stations for field sprayers:

- Control pressure gauge, diameter 150 mm, 0 – 16 bar, class 0.6.
- A patternot or a groove scanner with electronic data sampling with ridges on 100 mm and a length of at least 1.5 m, but preferably 1.8 m. The minimum working width is 12 m. With groove stands the sprayed fluid is collected in measuring glasses with a content of 500 ml. Marks are put on the glasses at 340 ml and 460 ml.
- A flow meter to measure the agitation capacity of the pump, accuracy 2 %.
- Ruler, revolution counter, tire pressure gauge, measuring glass, tools.

For test stations for air-assisted sprayers the following equipment is required:
• Control pressure gauge, diameter 150 mm, 0 – 16 bar or 0-25 bar, class 0.6.
• A vertical patternator with a minimum width of 100 cm and height of 350 cm. The distance between the lamellas is 33.3 mm; the accuracy of the glasses is 2 %.
• A flow meter to measure the agitation capacity of the pump, accuracy 2 %.
• A nozzle tester, the content of the glasses is 2 litres, the accuracy is 2 %. The adapters should be leak free mounted to the nozzle. Electronic nozzles testers are also permitted.
• Ruler, revolution counter, tire pressure gauge, measuring glass, tools.

Test operator: Test operators with an official certificate can only do tests. The testing station must have minimum one test operator.

3.3 Training of test-operators

The course for test operators is given at PTC+ in Ede. PTC+ is a practical training centre specialised in agricultural technique. For training the test operators for sprayer test, they have a complete test facility for training purpose with all the equipment. The training for test operator takes two days. The students are supposed to know the principles of the spraying technique before they start the course. The material for the course concerns as well the test itself as the administrative procedures. The examination consists of a theoretical and a practical part. The content of the course and the material used is approved by the SKL. The examination is under supervision of the SKL. There are different courses for test operators for field and air-assisted sprayers. Since the start of the courses, more then 900 persons have followed the training.

To assure the uniformity and to keep the level of the tests high, the test operators have to follow a one-day refreshment training every two-year.

4. Quality control

4.1 General

To assure the quality and uniformity of the sprayer tests, a system of quality control is necessary. To formalise the system of quality control the SKL is ISO 9001 : 2000 certified. The goal of the quality system is: The guarantee and improvement of the internal organisation and the service level to the relations.

The system includes: The primary processes (organisation of and control on the tests and also the execution of the tests by the testing stations) and the supporting processes (a.o. registration of all performed sprayer tests). Responsible for performance of the system is the project-leader. The system is kept accurate by an external quality-assessor; he also executes the internal audits. The external audits are done by LRQA.

Inputs for improvements of the system are:

• Results form internal and external audits.
• Complaints or remarks of the testing stations, the Product Boards, farmers, etc..
• Changes of the spraying technique or developments in test equipment.
• Changes of the national / European regulations.
• Results of the inspections of the test stations and tested machines.

A procedure is developed to implement the improvements in the system.

Every year the board of the SKL has a management-review of the system and determine the quality-goals for the next year.
4.2 Administrative quality control

The first part of the quality assurance is the administrative control. This exists of two parts. The first is the spreading of the actual documents to the testing stations (the manual, the right version of the test-reports, interpretation-file, stickers, etc). The second is an administrative control on all executed tests. The test stations send the copies of all test reports to the SKL secretary. Before putting them in a database there is control on the following points:

1. Is the test performed by a certified test station and a qualified test operator.
2. Is the test announced in advance.
3. Is the test form properly filled in.

4.3 Inspection of the test stations

All test stations are visited minimum once a year, the goal is 1.2 inspections per year. An inspector of the SKL performs the inspections. During the inspection the testing facilities are checked and the test equipment is controlled.

- The test facility has to be in conformity with the regulations
- The control pressure gauge of the test station will be compared with a more accurate pressure gauge of the inspector. If there are differences the pressure gauge of the test station has to be calibrated by an official calibration laboratory
- The flow meter of the test station will be compared with a more accurate flow meter of the inspector. In case of differences the flow meter of the station has to be adjusted.
- The patternator or electronic test stand is visually checked on good condition of the grooves and the glasses also the distance between the grooves is measured.
- At testing stations for testing air-assisted sprayers, the nozzle testing device is all checked.
- The most recent version of the test standards must be present.

4.4 Inspection of the performed tests

To get uniformity and quality of the executed tests, unexpected inspections of the tested machines are necessary.

To come to a system for planning the inspections, the testing stations are announcing in advance when they will test. On base of these announcements the inspections are planned to visit the stations by surprise. During the inspection it is checked if the machine is tested in conformity with the standards.

If possible the inspection of the tested machine will take place at the testing station. In case the test is ready and the machine left before the inspector arrived, the machine can be inspected at the farmers place.

To get an efficient control system the inspection of the testing station is combined with an inspection of the tested sprayer. Beside time-efficiency, the inspector gets a real impression of the test circumstances. The results of the inspections are summarised on an inspection form.

4.5 Sanctions

If the testing facilities are not good, the testing equipment is out of order or inaccurate, the sprayer is not properly tested, the tests are not announced in advance or the test is not executed by a qualified test-operator, sanctions will be given to the testing station. The shortcomings are divided into a category serious and less serious. Shortcomings in the category serious means that the tests have to be stopped till the shortcoming is raised; a re-inspection on the account of the testing station has to confirm that. After three serious shortcomings in a period of two years the board of the SKL can decide to cancel the approval of the station.
5. Results

Through the implementation of the ISO 9001 : 2000 Quality Assurance system, there is constant attention on a structured base for improvement of the system and the SKL-organisation. Consequent control of the returned test reports has resulted in a more uniform way of filling in the forms. In 2003 3 \% of the forms were sending back to the testing stations because of incomplete. During the inspection of the testing facilities is seen that most shortcomings occur with the groove test stands. Problems are: the distance between the grooves is too wide or too narrow, broken or unreadable glasses. 2 \% of the pressure gauges have to be calibrated every year. The flow meters are tested since half 2002. Last year 50 \% of the meters had to be adjusted.

In some cases the testing facilities were not good, too much influence of wind or wide sprayers cannot be tested properly. Other points of attention are the working conditions of the test operators, insufficient disposal of the exhaust gasses of the tractor and too less light. Another important goal of the inspections is a discussion with the test operator about the interpretation of the standards, about new developments in spraying techniques and nozzles and to give tips about more efficient testing. Attention is also given to the experiences of the testing stations with the SKL organisation (positive or negative), what can be used to improve the organisation.

In most cases the sprayers are tested in conformity with the guidelines. Sometimes there are some discussions. In some cases the sprayer was inspected to quick and got wrongly an approval.

In general the situation is that through the unexpected inspections the uniformity and quality of the sprayer tests has improved.

6. Conclusions and recommendations

With a system organised as in the Netherlands, with private firms carrying out the inspections, a well-balanced and certified quality assurance system is needed to get uniformity and equal quality of the executed sprayer tests.

The next elements are important:

- Clear testing standards for testing the machines, with clear norms to minimize the points of different interpretations.
- Clear requirements for the testing stations.
- Substantial training for the test-operator with periodical refreshing course.
- A good administrative control of the test reports.
- Unexpected inspections of the testing facilities and equipment during the tests.
- At-random inspection of the tested machines.

A uniform way of inspection the testing stations is preferably in order to prevent double or triple inspections of firms that build machines for more countries.

Attention should be paid to get a uniform content of the training of the test operators.
Results Session 4 - Quality management on inspections

1. Current situation in the Member States (MS) and candidate countries (CC)
   1. Quality of inspections is mainly managed by certification of inspection workshops, guidelines for testing and test equipment and by education of testing personnel.
   2. Some MS have established special quality management systems, in some cases externally certified.

2. Objectives to improve the current situation
   1. Uniform comprehensive guidelines for quality management
   2. Regular training courses for staff of inspection stations.
   3. Testing equipment needs regular check of its measurement accuracy.

   1. Development of quality management systems on inspection. Specifying minimum requirements on qualification of inspection personnel and on training courses.
   2. Exchange information how a better quality management can be introduced taking the specific national conditions into account.
Session 5 - Harmonisation of inspections for mutual recognition between Member States

Mutual recognition of sprayer inspections by Member States

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Summary

Sprayer testing for type approval, individual inspection of new sprayers and inspection of sprayers in use is differently organised in the Member States. This causes problems for those who cross borders with the machines e.g. farmers, contractors, manufacturers. In order to improve the situation measures should be taken to stimulate the use of EU-standards for tests, harmonise the organisational procedures and come to general mutual recognition between Member States.

The situation

For sprayers there exist several reasons for inspections: protection of the environment, labour safety and product quality.

This is done in practice by

- Type approval tests.
- Individual inspection of new sprayers.
- Individual inspection of sprayers in use.

1. Type approval tests

Governments can prescribe type approval tests for sprayers. Mutual recognition is important to prevent barriers to trade. The European Standards EN 12761-1, 2 and 3 describe a type approval test.

According to the CEN/CENELEC International Regulations, the national standards organisations of the following countries are bound to implement this European standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Implementing the standard probably means that the European standard shall be given the status of a national standard and that conflicting national standards must be withdrawn. Governments are free to make the standard obligatory, but if they apply a type approval, they should not use another standard. There is no sanction on this prescription.

2. Individual inspection of new sprayers

Even well designed new sprayers can have imperfections that result in bad sprayer performance. This can be all kinds of leakages, blocked sprayer nozzles or badly adjusted controls. A good quality system in a factory should include an individual inspection on faultless operation.

In the meantime, there exist several reasons and procedures for individual testing of new sprayers.

Germany requires a limited test within 6 months after first use of the machine. This test is often already done in the factory.

The UK has a voluntary test according to NSTS (National Sprayer Testing Scheme) in order to meet various requirements, including assurance schemes, processor/retailer production protocols as well as satisfying the desire of many farmers to verify the accuracy and overall fitness of their pesticide application equipment. Also the NSTS test is often done on new machines in the factory.
In the Netherlands the SKL (Foundation for Quality Control of Agricultural Equipment) has a test for sprayers in use which is obligatory every two years. This test is often done in the sprayer factory because the farmers also want a quality sign on new machines and several quality systems for agricultural products require that the spraying work has to be done with an (SKL) approved sprayer. There is no exemption for new machines.

International standards for this type of test do not exist but could be made. The procedures can be reduced versions of the tests for sprayers in use because the imperfections caused by wear and tear can be waived.

3. Inspection of sprayers in use

The mutual recognition is important for farmers in frontier regions with fields on both sides of the border. Especially for contractors this is also very important because they have customers on both sides of the border. Mutual recognition prevents double testing of the machines. The Dutch regulation states that sprayers owned by “entrepreneurs” from another Member State are allowed to be used in the Netherlands on the condition that they have a valid approval in the other Member State (free translation). This implies that the machines have to be tested in the country where the farmer or contractor is officially settled. In Belgium, the period between the tests is three years. It used to be so that Belgian sprayers used in the Netherlands had to be tested every two years and that shortcomings of the sprayers, noted in the Belgian test report as “to be repaired before the next inspection”, had to be repaired before use in the Netherlands was permitted. These limitations were lifted with the last change in the regulations.

The Belgian rule of 23 August 2001 (N2001 – 2391) states:

- Art 5. The farmers having residence in another Member State of the European Union may use their sprayers, not tested by Belgian authorities, on Belgian territory on the condition that the device has been tested by the authorities of that other Member State and has a valid approval (free translation). So, between Belgium and the Netherlands there are no problems with cross-border spraying. The only condition is that the sprayers have to be tested in the country where the owner is settled.

- With Germany there is a kind of unofficial agreement in the same sense. As long as no complaints arise, no further steps are taken. It happens that dealers of sprayers have customers in the neighbour country. They then want to offer the service of testing according to the procedure in the country of the user. SKL has approved a few German testing stations so that they can do SKL-sprayer tests. In such cases a few practical problems e.g. with regard to the language during the test operator training must be solved.

Problems of manufacturers:

Dutch manufacturers have a number of reasons to do tests on individual new sprayers before they leave the factory:

- End control in the production quality system of the factory

Netherlands quality systems for special qualities of agricultural products:

- The official regulation for testing of sprayers in use states that the test has to be done every second year, beginning 2 years after first use. For official and unofficial reasons the test is also often done on new machines.

Export to Germany:

- New machines have to be tested within 6 months after first use. In many cases the manufacturers do these tests already in the factory as a service to the farmer. Some German states accept the Dutch SKL-test, other states do not and require a BBA-test. The manufacturers have to fulfil the accreditation requirements of the German BBA to be authorised to do these tests. Manufacturers without BBA-authorisation have to organize the tests to be done somewhere in Germany.
Export to UK:

- For export to the UK an NSTS (National Sprayer Test Scheme) test certificate is desirable. Also for this the manufacturer has to have an authorisation.

Export to other countries:

- For several countries where inspection of sprayers is not required (France and other EU-countries), buyers often want inspection reports with the machines. For this purpose translated copies of the Dutch inspection reports are supplied by the manufacturers.

It is clear that the situation for the manufacturers is not very simple. They have to apply several more or less differing testing methods with equipment that has to fulfil different calibration procedures, they have to follow different training schemes for test operators and from time to time several authorities visit the factories to inspect the test facilities and the performance of the system. In cases where both field crop sprayers and orchard sprayers are produced, the complications are almost double. Simplification of the system is required.

Recommendations

- The desirability of an obligatory uniform type approval according to EN 12761 – 1, 2 and 3 should be considered, possibly by way of a European Directive on Environmental aspects of Machinery (parallel to the machinery directive on labour safety).
- A uniform inspection method for individual testing of new sprayers is desirable and the application should be made obligatory. This could be a simplified version of the test for sprayers in use. For example checking of parts that are influenced by wear and damaging could be skipped.
- As long as this is not put into action, mutual agreements could be made between controlling authorities in order to prevent too frequent visits to test facilities with authorisations for several tests.
- The EN 13790 –1, and 2 should be made obligatory in all EU countries by way of a European directive. As long as this is not done, EU-countries should accept without problems that machines officially approved in other countries work on their territory.
Mutual recognition between Germany and Belgium

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Summary

Throughout Europe and the world, official authorities as well as users are trying to rationalise the use of pesticides in agriculture. One of the privileged channels is the periodic inspection of sprayers. Different steps, compulsory or not, are established in many countries in order to test the functioning of sprayers and to improve the fleet of equipment. A problem can appear for the users living near the Belgian border and who spray crops in the neighbouring country. The countries concerned are: Germany, France, Luxembourg and the Netherlands.

The Belgian law specifies that “The compulsory inspection must be applied to all sprayers that spray on the Belgian area” and “Farmers being domiciled in other EU countries can use their sprayer in Belgium without a Belgian inspection only if this sprayer was inspected by this EU country and if they have at their disposal a valid report of inspection”.

For the countries that have a compulsory inspection, it is necessary to find an arrangement which allows mutual recognition. Since May 2003, a European standard exists to uniform, in the medium term, the technical protocol but the administrative management and constraints are and will probably stay different in each country.

In order to find a solution for the farmers living near the Belgian-German borders, a mutual recognition was established between these 2 countries.

1. Introduction

Germany has a long tradition regarding the inspection and testing of sprayers. Sprayers already in use have been inspected since the end of the seventies and a new sprayer declaration procedure started in 1986. The boom sprayer inspection has been mandatory since 1993. In Belgium the obligatory inspection of sprayers in use was implemented in 1995.

Organisations, protocols and cycle lengths differ from one country to another. In Germany, the inspection is conducted by private and certified stations, following a specific protocol based on pump flow rate, pressure and spray pattern measurements, with a cycle length of 2 years. In Belgium, the inspection is conducted by public and official stations, following a protocol based on pressure and flow rate measurements, with a cycle length of 3 years.

In 1998, Belgian inspection stations started to inspect the border region near Germany. As the Ministerial Decree (09 June 1995, published in the Belgian Official Journal of 12 August 1995) asks for a mandatory inspection for all sprayers working on Belgian territory, the German farmers who own some land in Belgium should also be inspected by the Belgian inspection station.

2. Description

2.1 History

In 1997, Belgium notified the European Commission of the mandatory sprayer inspection in compliance with Directive 83/189. Following a detailed opinion from Germany, the EC asked the Belgian authorities to precise article 5 which stipulated that all sprayers used on Belgian territory would be inspected. The sprayer inspection has been implemented for several years in Germany and some German farmers could use their inspected sprayers on Belgian territory in the border regions.
In January 1998, a bilateral meeting between Germany and Belgium was organised in Bonn (Germany) to debate the mutual recognition of the sprayer inspection.

2.2 The basis of the agreement

The aim of the mutual recognition is to avoid any double inspections of the sprayers used in both countries by farmers living in the border areas of both countries. Less than 100 sprayers are affected by this problem.

Although the protocol and the cycle length differed from one country to another, both national delegations confirmed that the qualitative objective was the same: the improvement of pesticide application. Therefore the mutual recognition method has been adopted by both delegations.

2.3 Legal translation

Both countries introduced «the recognition of the inspection done in a mandatory and official way in other European countries.» into their legal decrees.

The Belgian Ministerial Decree (31 August 1998, published in the Official Journal on 10 October 1998) stipulated in article 6: «Farmers resident in another Member State of the EU may use their sprayers in Belgium without being inspected by a Belgian authority, provided that their machine has been inspected in this Member State and they have a valid certificate.»

In the Regulation of Plant Protection Products and Plant Protection Equipment - Federal Bulletin volume 2003, part I, no. 57, issued in Bonn on 4 December 2003 – it is stated that there is not any obligation for inspection of sprayers if the inspection has already been carried out on the basis of the European standard EN 13790 and the last inspection was not more than 2 years ago.

This opens the possibility of coming to a general acceptance and mutual recognition of inspected sprayers in Europe.

3. Results and conclusions

Ahead of their time, Germany and Belgium showed a positive example for harmonising the national regulations for plant protection equipment. More than an example, this bilateral agreement should be the starting point of the constitution of a European network relating to plant protection equipment.

The Belgian-German experience focuses on the importance of the European directives and organs. The bilateral commission was set up after Belgium notified the European Commission of the mandatory sprayer inspection in compliance with Directive 83/189. The European standard EN 13790 has been introduced into the German regulation.

Although there remain some differences between the two countries, it is possible to find solutions through productive discussion and co-operation. SPISE should contribute to forwarding the process of harmonisation.

References


Belgian Steering Committee for the compulsory inspection of the sprayer, Report of the 8th meeting 26 February 1998, Ministry of Small Enterprises, Traders and Agricultural, Simon Bolivar Avenue 30, Bruxelles, Belgium.


Harmonisation of inspections – from bilateral agreements towards European solutions

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Summary

Various Member States have implemented schemes for the inspection of sprayers in use. These schemes diverge from each other and the common European approach is still missing. This contribution recommends the agreement on a common memorandum of the responsible, quality-conscious and forward-looking Member States to abandon today’s situation of bilateral agreements and to achieve a common European solution without asking for additional legislation.

1. Objectives

Crop protection in agriculture must follow three main objectives which are all equally as important:

- to produce high quality products (healthy and economically priced),
- to maintain a healthy environment,
- to improve the competitive position of European agriculture.

As products and environmental impacts do not stop at (non-existent) borderlines and farmers face competitors inside and outside Europe, at least European regulations are needed to cover the main factors important for crop protection.

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<td>Equipment / Sprayers</td>
<td>EN 12761-1, -2, -3</td>
<td>New sprayers</td>
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<td>Crop Protection Products CPP</td>
<td>91/414/EEC</td>
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<td>Application of CP Products</td>
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<td>- Good agricultural practice</td>
<td>National definitions and ISO activities</td>
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<td>- Condition of sprayers</td>
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<td>- Minimum criteria</td>
<td>EN 13790-1, -2</td>
<td>Sprayers in use</td>
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<td>- Inspection schemes</td>
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<td>Partly national schemes</td>
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</table>

Therefore, with respect to the inspection of sprayers in use, the final question is especially how to get EN 13790 applied within the European Community and how to agree on the missing specifications related to the competence of the inspectors, the equipment and the time intervals between inspections.
2. Options

2.1 Bilateral agreements between Member States

This means that two or more Member States – often direct neighbours – agree to recognise the inspection/certification of used sprayers done in the partner country. The main purpose is to allow farmers and contractors to work in the neighbour country without the need of re-certification.

The advantages of such bilateral agreements are:

- Resolving actual problems without pre-conditions or the need for consultation with other parties,
- Individual agreements without the need to modify one's own scheme.

The disadvantages can be seen as follows:

- Consumer protection is only partly given as not all products on the market are covered,
- Reinforcement of differences instead of harmonisation within Europe,
- Persistence of different conditions of competition within Europe.

2.2 EC Directive on sprayer inspection

This means to enforce the Member States by European legislation to implement schemes for the inspection of sprayers pursuant to harmonised specifications. Of course, this should be the normal procedure within the Community. But there is no other example of such a Directive.

The directives based on Article 95 of the treaties cover the placing on the market and putting into service but not the use and operation of products including the inspection at regular intervals and have the (only) objective of ensuring the free movement of products. Directives according to Article 137 include the use of machines but aim at ensuring safety at work by defining minimum criteria (see e.g. 89/391/EEC) and allow the Member States a vast window of opportunities for national implementation. The proposal for a new directive dealing with used machines was withdrawn in 1992.

Recapitulating we realise that it would be difficult to get the acceptance and the support for such a directive as:

- the expenditure of work is comparatively high to cover one very specific issue,
- amending 91/414/EEC which deals with crop protection products does not seem to be appropriate due to its completely different scope,
- it is a new field of activity,
- with regard to "lean" legislation and reducing bureaucracy, readiness to start new projects on directives is generally low.

2.3 Memorandum of Member States

This should be an agreement including mainly the following aspects:

- The requirements and tests for the inspection (reference to EN 13790),
- Specifications concerning the test equipment / test sites and the competence of the inspectors, and
- The acceptance of inspections / labels by the authorities of Member States having signed the memorandum.

This memorandum should be drafted and signed by the responsible, quality-conscious and forward-looking Member States and offered to all other Member States for joining. The European Commission should be asked to support this initiative.
This approach includes the following advantages:

- Member States are free to join the agreement at the appropriate time (harmonisation on optional basis),
- Member States intending to implement national schemes may/will use this agreement as guidance,
- No pre-conditions required – no need to wait,
- The technical details can be defined at expert level (see European standardisation),
- The agreement may be used as a basis for future EU legislation, if necessary, and
- The agreement will finally be accepted by all Member States as the inspection of sprayers is the right way to contribute to the objectives mentioned at the beginning.

3. Conclusions

The application of crop protection products is an essential contribution to secure food quantity and quality. Simultaneously, well-balanced economic conditions and the protection of the environment against negative impacts are requested. By Directive 91/414/EEC on crop protection products and international and European standards for sprayers, progress was made in achieving these objectives. But additional efforts are still needed to ensure the further improvement of product application. The ISO discussion on ‘good agricultural practice’ will be an essential contribution. Appropriate regulations for the inspection of sprayers in use are available but a common and unique application is missing. The proposed memorandum could offer the means to improve this aspect.
Results Session 5 - Harmonisation of inspections for mutual recognition between Member States

1. Current situation in the Member States (MS) and candidate countries (CC)
   1. Mutual recognition is obstructed by different existing regulations concerning sprayer inspection.
   2. In some cases, bilateral mutual recognition exists (ex: D/NL, B/NL).
      The acceptance of the inspection in other EC countries seems a good solution if the sprayer is moved to work throughout different countries (like the free circulation of cars): ‘Farmers and contractors resident in the EU may use their sprayer in the EU if it has been inspected by a Member State according to EN 13970 and they have a valid certificate’.
   3. The objective is to avoid any double inspection.

2. Objectives to improve the current situation
   1. To establish a uniform level of sprayer inspections throughout the European Union by application of EN 13790.
   2. Adoption of EN 12761,2,3 into the approval requirements in all MS for new sprayers.

   1. Installation of a European Steering Committee to ensure:
      - regular and strict checks of inspection stations’ activity,
      - reliability and accuracy of tests,
      - to discuss and solve all the issues concerning sprayer inspection (protocols, recognition, quality management, requirements …).
      - This shall provide European harmonisation of the inspection in order to avoid any discrimination between farmers in the EU (cost, severity, cycle…).
   2. Uniform approval procedure of new sprayers in all EU countries.
   3. Uniform procedure for sprayer inspection following EN 13790 and supporting documents (to be agreed).
   4. Establish a list of the key points for mutual recognition.

   New sprayers: Certification
   • Period to adapt new sprayers to Environment Standard EN 12761.

   Used sprayers: Inspection
   • Framework of administrative regulations for establishing an inspection.
   • Points to be considered see Session 2.
   • Parallel actions:
   • Farmers’ knowledge improving. Mandatory training courses (period of validity and revalidation), information campaigns.
   • Farmers have to be convinced about the usefulness of an obligatory inspection system.
   • To work in the framework of the ISO WG on GAP.
   • Introduce voluntary calibration to inspection.
Session 6 - Concluding remarks

Recommendations of the Workshop ‘Standardised Procedure for the Inspection of Sprayers in Europe – SPISE – ’

The aim of the workshop was to introduce the new standard EN 13790 to all European Member States and candidate countries and to encourage its implementation in order to be able to provide the most reliable equipment inspections possible for the future. The participants welcomed this initiative of the BBA and expressed their expectations to continue efforts toward harmonising plant protection equipment inspections with the following resolution:

Resolution

Taking into consideration that

- plant protection is an essential instrument for ensuring sufficient high-quality and healthy food,
- justified demands of consumer- and environmental protection and nature conservation are to be implemented in the interests of society and politics,
- technical equipment is particularly important in complementing the application of authorised plant protection products according to good professional practice,
- MS and EC are at present discussing possible measures for improving the sustainability of plant protection,
- with the publication of European standard EN 13790 ‘agricultural machinery – plant protection equipment – the inspection of plant protection equipment already in use’ – part 1: boom sprayers and part 2: sprayers and air-assisted sprayers for bush and tree cultures - and the technical demands placed on equipment mentioned here, an important element for the harmonisation of equipment inspections has already been created,
- further regulations such as administrative regulations required for establishing inspections, technical prerequisites for conducting inspections and quality management systems are necessary for equipment inspections of a high technical standard and comparable quality throughout the Member States and candidate countries.

It is welcomed by the participants of the SPISE-Workshop

- that the EC and the Member States intend to improve the sustainability of plant protection through suitable measures, and are at the same time contemplating the introduction of an equipment inspection in the Member States (MS) and candidate countries (CC) as an important contribution to proper plant protection characterised by its sustainability.

The participants would also welcome the thought that

- the EC, MS and CC would all continue their efforts to harmonise equipment inspections and to promote mutual acceptance; here it is deemed particularly important that existing or new inspection systems in the MS correspond with uniform, European measures with an appropriate degree of subsidiarity (the timing will not be left fully to the MS but they will be able to accommodate their own specific terms and conditions) steered by a European Committee,
- a working group (BE/NL/IT/FR/DE) where to work on further steps for the harmonisation and mutual acceptance of equipment inspections and where to prepare a second European SPISE-Workshop for 2006,
- a constant exchange of information were to be made possible between the working group and consultations going on between the EC and MS on improving the sustainability of plant protection.
Exhibition and demonstration of inspection facilities

The lectures were complemented by an exhibition of inspection facilities from workshops/manufacturers/distributors at the Application Techniques Division and an excursion to officially recognised inspection centres – which are approved by the Plant Protection Service of the Federal States (Laender) to carry out equipment inspections in accordance with the BBA directives.

Figure 1: Test stands for measuring the single nozzle outlet and the vertical distribution (Pessl).

Figure 2: Trailer of the Norwegian inspection equipment with the transverse distribution test stand (Lurnarc).
Figure 3: Test equipment for inspection of manometer, pump capacity, single nozzle output and posters (aams) inside of the testing hall.

Figure 4: Test bench for measuring vertical patterns of the sprayers used in “pergolato”-trained vine yards (Pulcinelli).
## List of exhibitions

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<td>Inspection equipment</td>
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<tr>
<td>Nils Bjugstad, NLH Agricultural University of Norway</td>
<td>Trailer with Inspection Equipment</td>
</tr>
<tr>
<td>Leopoldo Franceschini, CEO Extel srl</td>
<td>Equipfit mobile inspection centre (vertical bench with vertical plates for tree crop sprayers and horizontal test bench for field sprayers)</td>
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<tr>
<td>Ernst Herbst, Herbst Prüftechnik</td>
<td>Test benches and computer aided measurement systems: Sprayer test 1000, Nozzle tester ED 16, Flowmeter, vertical test bench</td>
</tr>
<tr>
<td>Michael Stimm, LH-Agro GbR</td>
<td>Inspection Equipment for field sprayers</td>
</tr>
<tr>
<td>Olivier Mostade, Ministry of small Enterprises, Traders and Agriculture Chaussée de Namur 146, B – 5030 Gembloux</td>
<td>Van equipped with test facilities</td>
</tr>
<tr>
<td>Giovanni Pulcinelli, Via delle Chiarebbelle 22, I – 52031 S. Leo Di Anghiari (Ar)</td>
<td>Test-bench and computer aided measurement system for checking and calibrating spraying machines used in tendone trained vineyards</td>
</tr>
<tr>
<td>Wilhelm Pachler, Pachler Metallbau A – 8324 Kirchberg/R. 12</td>
<td>Inspection equipment for sprayers used in orchards, vineyards and hops</td>
</tr>
</tbody>
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Excursion for visiting approved workshops

The excursion to officially recognised inspection centres leads first to the Raiffeisen Hauptgenossenschaft Hannover, Branch Deensen. This farmers cooperative uses some special sprayer inspection trailers, which are used in many inspection workshops in whole Lower Saxony. The test facilities stored in these trailers make it possible to carry out the complete inspection of field sprayers and in some cases of air-assisted sprayers too.

During the visit one group joined first the measurement of the cross distribution using a spray scanner, fig. 1. The other group participated first the measurement of pump capacity and evaluation of the general feature.

A second approved workshop, Hobein Company, Coppenbruegge was visited for participating in a practical inspection of a field sprayer using a groove patternator with electronic measuring device, fig. 2.

Figure 1: Measuring the cross distribution by using a spray scanner.

Figure 2: Evaluation of cross distribution by using a groove patternator with electronic measuring device.
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