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

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

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

Introduction

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

The EU Directive has been incorporated into the national legislation via the National Action Plans. Every single MS has been in charge to develop its own legal framework in

order to guarantee the mandatory accomplishment established by EU (Gil et al., 2012; Wehmann, 2009). In the specific case of Spain, the criteria for conducting mandatory inspections are laid out in an Inspection handbook (Gil et al., 2011) edited by the National Authority. This handbook, as occurs in other MS (Balsari et al., 2009; Nilsson and Palsson, 2009) has been established as official guide to help the inspectors to fulfil all the requirements during the inspection procedure.

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

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

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

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

The objective of this work was to present two important tools already developed in Spain in order to arrange the mandatory inspection of sprayers in use: a dedicated software

to help inspectors during the inspection process, and the official Manual of inspection of sprayers in use adpoted by the Spanish Government as training material during the organized courses.

Software for inspections: a need

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

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

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

- Create data collection protocols according to the Inspection handbook or other available official requirements, from the National Authorities.
- Specify different options concerning available hardware ready to directly acquire inspection data without the use of inspection sheets, even in adverse weather conditions of high humidity and low visibility.
- Specify an energy self-sufficient hardware and software system.
- Establish an order of data collection by taking into account the operating sequence of the tractor engine.
- Provide a checklist and database of nozzle and sprayer manufactures to expedite data collection.
- Create a database with information that needs to be transferred to regional and central authorities.
- Generate data files, in the standard format set by the National Authority, to be transferred to the regional and central authorities.
- Calculate the quantitative data related to errors in flow nozzles, the reference manometer pressure and sprayer pressures.
- Issue the inspection report and the inspection certificate.
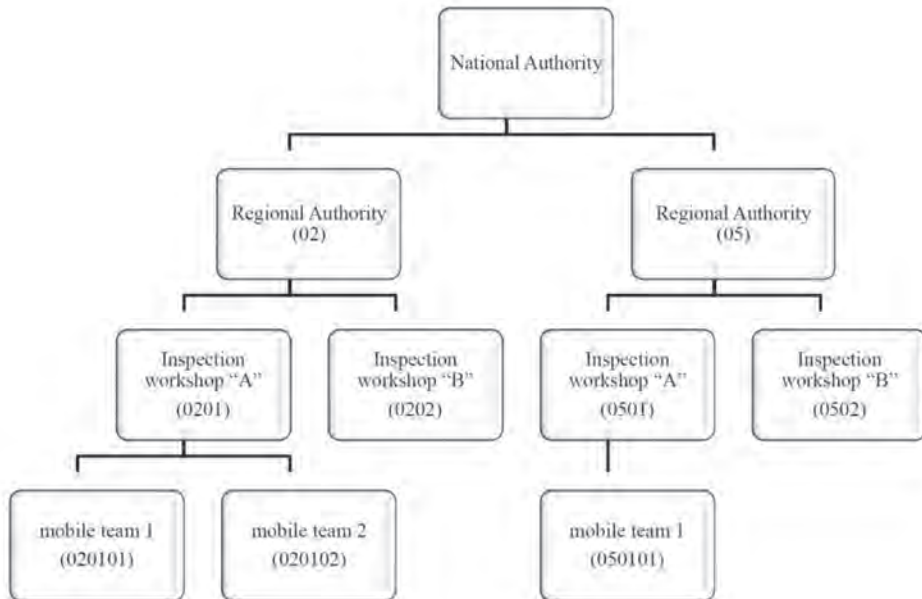
Fig. 1. Example of relationships between the users of the software. National Authority: Ministry of Agriculture; Regional Authority: Autonomous Community (first-level political and administrative division).

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

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

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

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

Software development and structure

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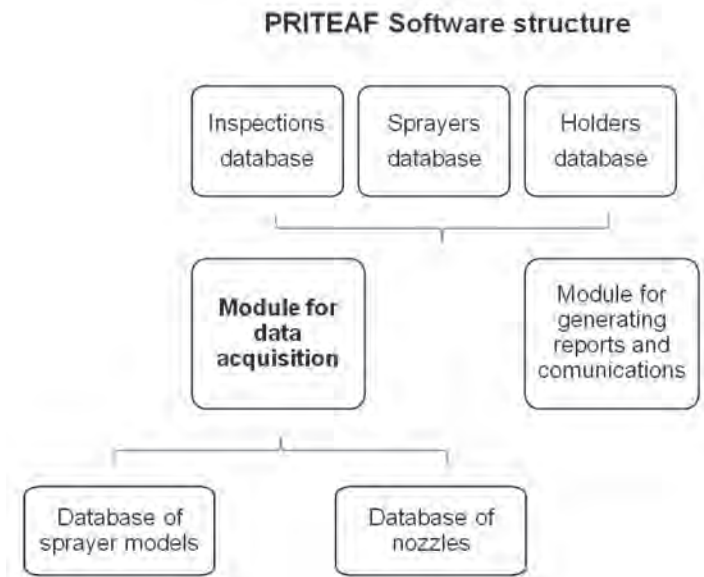
Fig. 2. Architectonic structure of PRITEAF software.

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

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

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

Fig. 3. Hardware required by PRITEAF software.

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

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

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

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

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

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

Manual of inspection of sprayers in use

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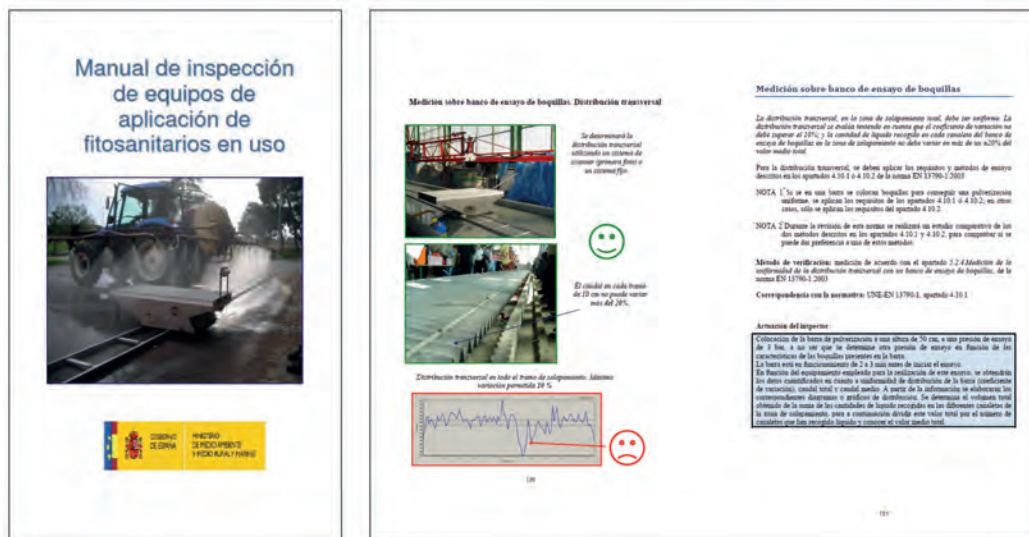

Fig. 4. Manual for inspection of sprayers in use. Main page (left) and structure (right). Available at www.uma.deab.upc.edu and www.magrama.es.

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

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

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

Conclusions and remarks

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

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

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

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

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

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

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

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