

## Session 1: present experiences and challenges in inspections activities

### BTSF training course on Pesticide Application Equipment: Eight years of education on inspection benefits around Europe.

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#### Summary

Better Training for Safer Food programme (BTSF) is an educational program financed by the European Commission under DG SANTE. Among the large educational offer included within the BTSF Academy, several actions related to the use of pesticide equipment have been included. In 2016 it was arranged an official training course focused on Pesticide Application Equipment, where the two specific topics to be addressed were inspection and calibration of all type of equipment used in Europe to distribute Plant Protection Products. During the last eight years period (2016-2023) a total of 18 one-week training courses have been arranged in different European locations (Barcelona, Montpellier, Wageningen, Turin and Braunschweig) housing more than 350 attendants, all of them representing local authorities, advisory centers, research and academic institutions. Topics as the new European rules and international standards concerning the inspection of sprayers in use, methodology and equipment for a good inspection procedure, aspects related to quality and quality control of the inspections, and an interesting list of topics focused on a proper use of spray application technologies have been addressed mixing theory and practical activities. This paper will show interesting data about degree of knowledge and implementation of inspection of sprayers around the different MS, and main problems and difficulties to be addressed to achieve a harmonized and uniform situation in Europe. The document will include a detailed evaluation of results obtained during pre and post training exam. Efficacy of training activities has been measured, including a specific evaluation of the different type of questions addressed to the attendants. All this information has been obtained on an anonymous way.

**Keywords:** Plant Protection Product, Treatment, Sprayer, Knowledge, Extension.

#### Introduction

Agriculture in Europe is always a strategic sector, which provides great economic, social, territorial and environmental value. Despite the fact that the advance of industry and services has brought with them a gradual loss of importance of the agriculture within the economy since the last century, European agricultural production has not stopped growing in absolute terms (EP, 2021). However, the strategy of intensive agriculture has been based on obtaining higher yields thanks to a greater amount or frequency of application of inputs, such as Plant Protection Products (PPP). Besides this, the phytosanitary control of crops also means defining a product application technique for its correct distribution, for which it is necessary to have, first, the appropriate Pesticide Application Equipment (PAE) for each product and type of crop and, consequently, make correct use and good maintenance of the machine.

However, it is known that during pesticide applications not all of the sprayed product reaches the target vegetation. A fraction of the spray volume evaporates as it goes outside before reaching the leaves, another part falls directly to the ground and another part is dispersed following environmental air currents away from the target plant/tree. Unwanted product losses could harm the biodiversity of the local ecosystem, the health of people, and contaminate water resources, such as aquifers and groundwater drains. These problems are aggravated if the PAE used by the grower does not meet the minimum requirements demanded by the European Directive for a Sustainable Use of Pesticides (SUD) (EC, 2009), which guarantee that the equipment works correctly. If, in addition, the sprayer is not calibrated, the losses are even greater.

It is clear that European agri-food system must face a gradual change in the food production model over the next few years. A first step was the Directive 2009/128/EC (currently, a new version is under discussion). Now, the European Green Deal (EC, 2019) is a tool to fight climate change that aims to make Europe, by 2050, the first climate neutral continent. This pact proposes a progressive limitation in the number of conventional agricultural inputs, together with a promotion of ecological practices and landscapes rich in biodiversity, all through the Farm to Fork and Biodiversity strategies (EC, 2020ab). Therefore, Europe looks to the horizon and considers a progressive limitation of conventional agrochemicals. Until 2030, 50% reductions in the use of pesticides are pretended.

The use of new spraying technologies, the design of new sprayers, the development of Decision Support Systems (DSS) or precision agriculture techniques are essential to achieve these intended objectives. Nevertheless, the implementation of these new technological advances among the farmers will not be effective as long as end users fully assimilate the basics of sprayer calibration and adjustment. In this sense, advisors, institutions and administrations also have an important role in the field of training and extension of the Best Management Practices (BMP) to establish a solid base on which to project a sustainable strategy for the use of PPP, such as the BTSF (Better Training for Safer Food) initiative promoted for years by CHAFEA (Consumers, Health And Food European Agency). This program organizes training activities on one of the most important aspects for the correct use of sprayers: inspection and calibration according to the Directive 2009/128/EC through ISO standard 16122 (ISO, 2015), which exposes the methodology for a complete evaluation of the PAE. Activities include knowledge tests before and after the course. In this way it is possible to know where the attendants had more difficulties at the beginning of the course and the progression after the training. This communication aims to summarize these knowledge questionnaires from 2016 to the present.

## **Materials and methods**

The CHAFEA, by means of the Directorate General for Health and Food Safety (DG SANTE), started in 2014 an official course centered on the description, inspection, adjustment and the correct use of different PAE (boom sprayers, airblast sprayer, knapsack sprayers...), always within the BTSF program, including theoretical content (European strategies, machines, standards, environmental requirements) and practical demonstrations with real sprayers. Currently, this program is not only still in force, but also continues to update its contents to regularly train those interested in the latest developments in European regulations, PAE and other related trends.

The BTSF course is aimed at members of different organizations (public, private, mixed), professional activities (inspection, consultancy, public administration...) that interact, directly or indirectly, with farmers and PAE users, as well as with the correct compliance with environmental regulations that are related to crop protection management. More than 350 interested parties from all over the European Union (27 countries), as well as some representatives from third countries as Bosnia, Norway and Albania, have attended these one-week courses. These courses have been done in different academic centers: Polytechnic University of Catalonia (Barcelona, Spain), National Research Institute for Agriculture - Food and the Environment (Montpellier, France), Wageningen

University & Research (Wageningen, Netherlands), University de Turin (Turin, Italy) and Julius Kühn-Institut (Braunschweig, Germany), with the external support of AINIA Institute of Technology (Valencia, Spain) and AETS Consultants (Lons, France).

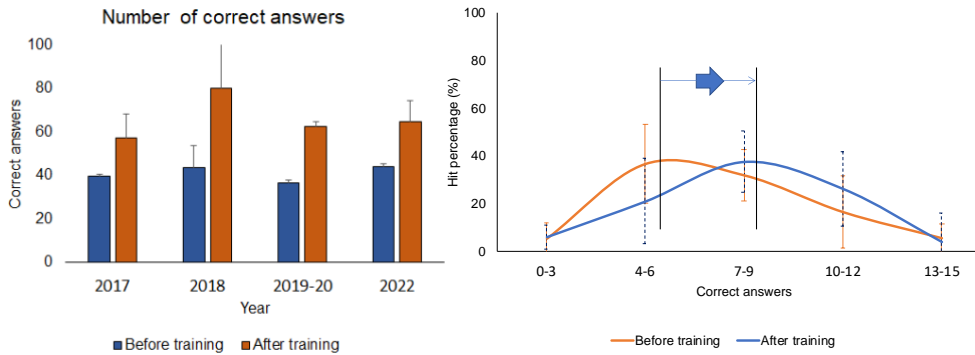
On the first day of the course, before starting with the subject matter and the practical classes of the course, a theoretical knowledge questionnaire on the inspection and calibration of sprayers is distributed to each of the course attendees. This questionnaire is done individually. The objective is to evaluate the level of preliminary preparation that all those interested in the course have. The tests presented 15 questions, which evaluated the impression of those questioned about different factors that affect sprayers, European directives (SUD), ISO standards for sprayers or the calibration of equipment before doing a phytosanitary treatment with a certain type. of machine. Each question has four potential answer options, although only one option is correct. If a question is answered incorrectly, this did not imply a penalty on the final score of the test. Attendees can respond freely, always under the protection of anonymity, so no one knew that someone else had answered. The responses to each of the tests are immediately recorded digitally. From each test, it is obtained a mark that goes from 100% correct (15 correct questions out of 15) to 0% correct (not a single question answered correctly). More than 7 correct answers are taken as an adequate level to consider that the person has a minimum base to work in the inspection and maintenance of the sprayers. In this way, it is possible to determine the average level of the knowledge base among all course participants. Similarly, the percentage of correct answers obtained in each of the questions that make up the questionnaire is also evaluated. In this way, knowing that the questions can be classified into different blocks by theme, it is possible to better understand which are the aspects where the participants of this training course have more room for improvement.

Finally, on the last day of the same course, the attendants complete a new questionnaire, which is exactly identical to the one they completed on the first day. This is done with the idea of estimating and quantifying the degree of improvement of all participants with respect to all the points explained throughout that week. This questionnaire is also anonymous and the results are also recorded by computer for later evaluation. Once again, the response percentages of each of the questionnaires are obtained, as well as the percentage of correct answers answer by answer. The latter provides more detailed information on whether the people have been able to understand and assimilate all those aspects that, according to the answers to the first questionnaire, seemed to have more complications. In this regard, the results (before and after the course) of the last 8 years have been represented together to be able to trace the general trends for the different questions and have a first evaluation of the global impact that this BTSF course has, for the inspection of PAE and the implementation of BMP.

## **Results and discussion**

### *General knowledge level of the attendants*

Figure 1a summarizes how the general behavior of the stakeholders has been throughout the different courses in recent years before and after starting the activities. The average number of questions answered correctly before starting the courses was 6 out of the 15 questions asked (40% correct), with a standard deviation of 1 answer, which indicates that this behavior has been very common these years among the academic centers. On the other hand, after the end of the program, all attendees improved their grades, with an average of 10 correct responses out of 15 (67% correct). This value was also very representative, since the standard deviation was 3 answers, reaching up to 12 or more correct answers in some events. This difference reflects a positive trend regarding the progression of the participants in the course, which was also always fulfilled. This improvement could be quantified in an average ratio of 67% with respect to the test at the beginning of the course.



a) Mean number of answers      b) Attendants with a score  $\geq 7$

Figure 1. General balance of results since the questionnaires began to be prepared: mean number of correct answers per year (left side) and hits percentage answered (right side). The years 2019 and 2020 are grouped together due to the few data collected due to the effects of the pandemic, which avoided activities in much of 2020 and throughout 2021. Standard deviations are represented as bars.

In more detail, Figure 1b summarizes the hits percentage obtained at different intervals of marks. At the start of the week, an average of 50% of attendees answered half of the questionnaire correctly. However, this percentage was reduced to only 25% of attendees in any course. On the other hand, at the end of the course and answering the questionnaire again, 77% of the attendees correctly answered 7 or more of the 15 questions on the form, reaching 100% of the participants on a couple of occasions. Once again, this improvement after the course was noticeable, with an average increase of 44% between before and after the training activities in the same course.

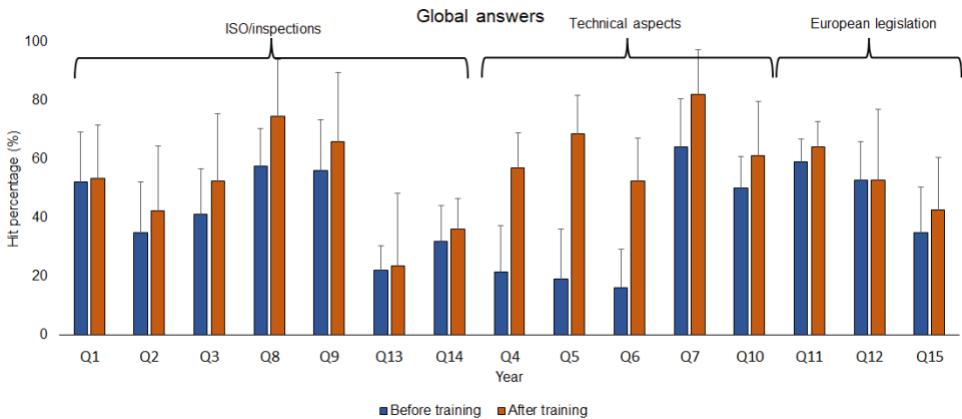


Figure 2. Percentage of correct answers for each of the fifteen questions formulated in the questionnaires before and after the course. Three blocks have been differentiated based on whether one of the following points was directly asked: European legislation, ISO/inspections and technical aspects of PAE. Standard deviations are represented as bars.

Figure 2 shows the percentage of correct answers for each of the questions. Although all the questions were related to each other, forming a very transversal questionnaire, the questions could be classified into three large blocks of questions depending on whether they asked directly about European legislation, inspections and ISO standards, and technical aspects of the PAE. For European Directives, only in 49% of the cases was answered adequately before starting the course. This

improves after the course, when it reaches 55% correct answers, which implies a mean increase of approximately 12%. Therefore, the course shows, on the one hand, the lack of knowledge on the part of stakeholders in the European sustainability strategy in PPP and, on the other hand, its usefulness to reduce these differences. For the block of ISO/inspections, the percentage of correct answers always increased when the same questions were asked again to the course members, when the training week ended, except in 2018 where the percentages of correct answers were very close (48% before the training and 52% later). Nevertheless, the overall balance is positive, with a mean value of 44% correct answers before starting the course and 52% afterwards, which implies a progression of 18%. Finally, regarding the technical questions, this block is the one that showed the most improvements before (mean value of 30% of answers answered correctly) and after the training (with a mean value of 67%). This has been a characteristic trend every year, with differences of more than 50% in the courses between 2018 and 2020.

### European legislation

Although the European Directive 2009/128/EC was very present in the questionnaire in one way or another, there were only four questions that directly referred to this Directive (Figure 3). Therefore, this block of questions has been considered to represent a very approximate estimate of the knowledge that the attendants had in the BTSF courses on European legislation. Specifically, the questions were about: 1) Mutual recognition of PAE inspection certificates (Q10); 2) current regulation of aerial application of PPP (Q11); 3) role of SUD on the PAE calibration (Q12); and 4) type of PAE which may be exempted from the periodical inspections (Q15). The proper answers to each of the questions are examined: 50% of the attendants at the beginning of the course answered correctly that according to Directive 2009/128/EC mutual recognition of PAE inspection certificates means that Member States shall endeavor to recognize the certificates issued in other Member States; 59% responded that aerial application of PPP is prohibited and, only by derogation, it may be allowed in some particular cases; and 35% said that the equipment not used for spraying may be exempted from the periodical inspections. All these values improved to 61, 64 and 43%, respectively. Only the question about the calibration presented a similar percentage before and after the course, asking if SUD provides for professional users to conduct regular calibration and technical checks of PAE (around 53%). However, if the data for the 2019-2020 period (abruptly interrupted by the pandemic) are not considered, the number of correct answers after the course would increase to 56%.

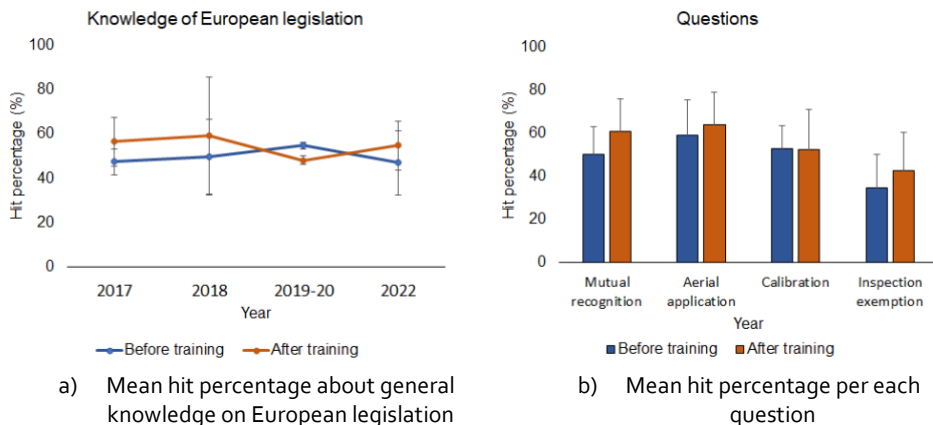
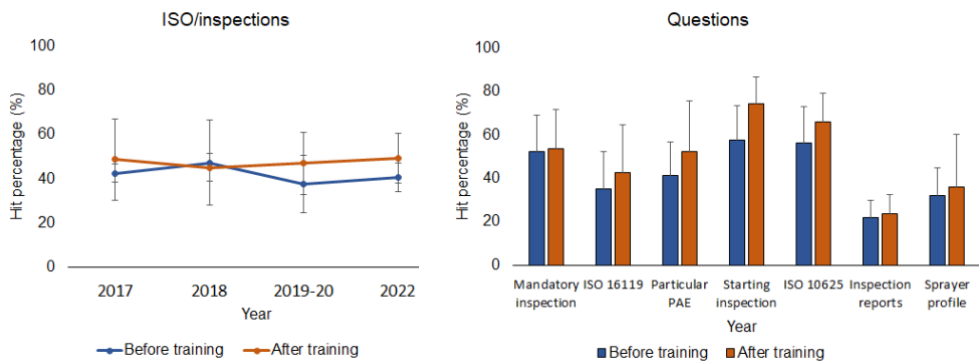


Figure 3. General balance of answers corresponding to the European legislation since the questionnaires began to be prepared: evolution of mean total percentage of correct answers (left side) and particular questions (right side). The years 2019 and 2020 are grouped together due to the few data collected due to the effects of the pandemic, which avoided activities in much of 2020 and throughout 2021. Standard deviations are represented as bars.

## Inspections and ISO standards

The specific legislation on inspections of sprayers and its practical application through the ISO 16122 standard, as well as other ISOs related to PAEs, are another of the most important aspects on which the BTSF program affects (Figure 4). In the questionnaire there are up to a total of seven direct questions about PAE inspections and the use of ISO standards: 1) Origin of the regulation of PAE inspections (Q1); 2) the usefulness of the ISO 16119 (ISO, 2013) standard for the design and performance of sprayers (Q2); 3) a particular case of PAE inspection (with a photo attached) (Q3); 4) prerequisites before starting an inspection according to ISO 16122 (Q8); 5) interpretation of the agricultural spray nozzles code according to ISO 10625 (2018) (Q9); 6) assessment of the vertical distribution of an air-assisted sprayer (Q13); and 7) European inspection reporting requirements (Q14). Observing the hits in detail, an improvement was observed in all the questions in the percentage of correct answers, although with a different intensity depending on the type of question: the number of attendants stating that mandatory inspection of sprayers in use must be carried out in MS required by Annex II of European Directive 2009/128/EC increased by 4%; regarding the compliance of ISO 16119 allows sprayer's manufacturers to fulfill the mandatory requirements of the European Directive, there were 8% more attendants giving this option as correct; the percentage of hits on the specific case of PAE was 14% higher; the number of attendants saying that the start of inspections considering the importance of PTO protection was a fundamental requirement was 18% higher; and the interpretation of ISO 10625 also improved by 10 percentage points. The most difficult questions were the concerning the inspection reports and the liquid profiles distributuin, where there is only an improvement of 1% and 3%, respectively. These two questions present the lowest number of hits, both before and after the training course. For example, about the inspection report, the maximum percentage achieved is 43% to date regarding. Stakeholders seemed to have better assimilated those topics related to the applied part of the inspection protocols, an issue that is addressed in depth in the courses.



a) Mean hit percentage about general knowledge on inspections and ISO

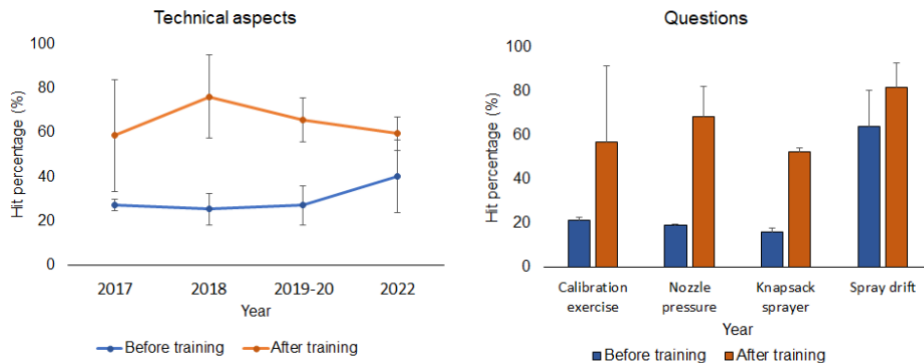
b) Mean hit percentage per each question

Figure 4. General balance of answers corresponding to inspection regulation since the questionnaires began to be prepared: evolution of mean total percentage of correct answers (left side) and particular questions (right side). The years 2019 and 2020 are grouped together due to the few data collected due to the effects of the pandemic, which avoided activities in much of 2020 and throughout 2021. Standard deviations are represented as bars.

## Technical questions

Figure 5 shows the overall and individual results for the remaining four questions, concerning questions related to calibration and drift. The questions asked to the attendants were: 1) a horizontal boom sprayer calibration exercise (correctly resolved in 21% of cases before the course and 59%

after) (Q4); 2) the relation between pressure and flow of an ISO nozzle (correctly solved by 19% of the participants before the course and 72% after) (Q5); 3) the choice of a knapsack sprayer (answered appropriately by 17% of the members before the course and 54% after) (Q6); and 4) the definition of spray drift (64% correctly said it was air-borne droplets above the adjacent field and 83% later) (Q7). This improvement indicates the lack of technical knowledge of many assistants (many of them come from public administrations) and how the practical activities carried out in agricultural mechanization laboratories help to alleviate this fact.



a) Mean hit percentage about general knowledge on technical aspects of spraying

b) Mean hit percentage per each question

Figure 5. General balance of answers corresponding to other technical points since the questionnaires began to be prepared: evolution of mean total percentage of correct answers (left side) and particular questions (right side). The years 2019 and 2020 are grouped together due to the few data collected due to the effects of the pandemic, which avoided activities in much of 2020 and throughout 2021. Standard deviations are represented as bars.

## Conclusions

The results of the questionnaires show that these courses serve to detect complications of interpretation and application of the European Directive 2009/128/EC and the ISO standards for inspection and design of sprayers. It also serves to significantly improve the skills of stakeholders through the experience gained during the course, as well as the material and knowledge provided by experts from the corresponding institutions. These results also highlight the fundamental importance of training to achieve the objectives proposed by the European Green Deal.

## References

EC/128. Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides; 2009 [Of. J. EU, 24.11.2009, L 309/71].

European Commission. (2019). Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, the European Green Deal. European Commission: Brussels, Belgium.

European Commission. (2020a). Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. European Commission: Brussels, Belgium.

European Commission. (2020b). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, EU Biodiversity Strategy for 2030. European Commission: Brussels, Belgium.

European Parliament. (2021). EU agriculture statistics: subsidies, jobs, production (infographic). European Parliament: Brussels, Belgium.

International Standardization Organization. (2013). ISO 16119. Agricultural and forest machinery - Environmental requirements for sprayers – Parts 1, 2 & 3. Geneva, Switzerland: ISO.

International Standardization Organization. (2015). ISO 16122. Agricultural and forestry machinery - Inspection of sprayers in use – Parts 1, 2 & 3. Geneva, Switzerland: ISO.

International Standardization Organization. (2018). ISO 10625. Equipment for crop protection — Sprayer nozzles - Colour coding for identification. Geneva, Switzerland: ISO