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Orchard sprayer's evaluation according to ISO 16119-3. Need to support manufacturer's procedure

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Summary

Since the publication of European Directive (2009/127/EC), environmental requirements for new orchard sprayers are mandatory. Only equipment which has successfully accomplished the specifications can be placed into the EU market. For this purpose, the new harmonized ISO 16119 series represents an interesting tool to fulfil the requirements. In order to evaluate the difficulties to accomplish the official requirements, a new orchard mistblower (2000 L Inverter Qi 9.0 Ecoteqi) was evaluated following the corresponding standard. During the evaluation process a large list of complementary standards was identified to be accomplished for the purpose. The tests associated were complex, expensive and time-consuming. Parts of the standards were detected as undefined criteria or not clearly adapted for orchard sprayers. All these difficulties represent a great challenge for most SME manufacturers all around the EU. All these reasons underlined the need to improve the relationship between sprayer's manufacturers and national representatives on International Standardization Bodies. As a consequence, a practical guideline for Spanish sprayer's manufacturers has been developed by UMA-UPC in order to enlarge the knowledge of ISO 16119 series and its practical application.

Key words: ISO 16119, environment, air-blast sprayer, evaluation, guideline

Introduction

Air assisted orchard sprayers are usually employed for spray application in vineyards and fruit crops. The turbulent air current generated helps to transport the droplets, penetrating the vegetation while moving leaves and branches (Salcedo *et al*., 2015). But only a part of the product reaches the tree (Garcerá *et al*., 2017). The rest of the applied volume ends up in the atmosphere (Zivan *et al*., 2017) or on the ground (Patinha *et al*., 2017). These off-target losses can suppose a negative effect to the environment (Gustavsson *et al*., 2017) and human health (Kim *et al*., 2017). Several factors influence the application's efficiency such as the wind action (Grella *et al*., 2017), canopy characteristics (O'Donnell *et al*., 2017) or characteristics of selected spray technology (Dekeyser *et al*., 2013).

In order to avoid potential risk of contamination, the sprayer shall be in optimum condition, without any leaks or dangerous areas to the driver. The prototype should be designed to apply the product efficiently, minimizing losses and waste and allowing complete cleaning of the equipment (Miranda-Fuentes *et al*., 2017).

But, other than weather conditions, working parameters and canopy characteristic, efficiency and quality of any spray application process require a correct, safe and well calibrated sprayer. For that reason, in October 2009 two European Directives were published focused on the use phase

of pesticides (Gil, 2006): European Directive 2009/128/EC for Sustainable Use of Pesticides, addressing among other aspects the mandatory inspection of sprayers in use in Europe; and European Directive 2009/127/EC amending 2006/42/EC with regard to the spraying equipment, establishes the essential environmental and safety requirements to be accomplished for new sprayers. European sprayer's manufacturers shall take all appropriate measures to be sure that their machinery may be placed on the market and put into service accomplishing the relevant provisions established in the legislation. For this reason, following the Directive 2009/127/EC, the European Commission and European Free Trade Association required to the European Committee for Standardization a standard for new sprayers to indicate to the manufacturers the minimum conditions for the different aspects of the machine (cleaning system, agitators, induction hoppers, etc.) to diminish environmental risks. As a consequence, a new ISO 16119 series (ISO, 2013) was published in June 2014 as a harmonized standard in the Official Journal of the EU as a tool to help the sprayer's manufacturers to fulfill all the mandatory requirements. Part 3 of this standard is focused on sprayers for bush and tree crops. However, not all sprayer's manufacturers have facilities, devices and expertise to accomplish all the requirements, and even more, there are some tests included in the standard with a high level of complexity. In order to quantify the difficulties and the practical needs to apply the ISO 16119-3 to a brand-new sprayer, the UMA-UPC research group arranged a complete test of a new trailed air assisted orchard sprayer (FEDE Inverter) with a volume tank of 2000 L following ISO 16119-3. During the test particular attention was addressed to the practical difficulties (materials, water consumed…) encountered, to the resources and time request, in order to develop practical recommendations about the whole process of application.

Materials & Methods

Location and sprayer

Tests required in ISO 16119-3 were carried out at the Laboratory of Agricultural Mechanization of UMA-UPC (https://uma.deab.upc.edu) in Viladecans (Barcelona). The selected sprayer was a FEDE Inverter Qi 9.0 Ecoteqi (Fig. 1) with technology H_3O (Pulverizadores Fede, S.L., Cheste, Spain).

Fig. 1. Selected FEDE sprayer (left) and detail during cleaning test (right) at UMA-UPC facilities.

The sprayer had 14 nozzle holders, with double outlet, divided into two symmetrical sections (seven nozzle holders in each side). The sprayer was equipped with five disc-core nozzles model D3-DC35 and two D3-DC25 (TeeJet, Spraying Systems Co., Wheaton, Illinois, USA) in both symmetrical sides. The nozzles DC25 were placed in the lowest position of the arch. The sprayers were also provided with an alternative set of D4 nozzles in the nozzle holder. Five lot positions were provided with nozzles D4-DC35 and two more with D4-DC25.

Complementary required standards

A complete fulfilment of ISO 16119-3 requires the complementary use of a large list of other standards. These standards (Table 1) are required to complete the assays/verifications included in ISO 16119-3. This situation represents one of the most difficult aspects from the sprayer's manufactures, which in general are not provided with such a large list of standards.

Table 1. Complementary standards included in ISO 16119-3

ISO	Corresponding test
4254-6	Measuring system
4288	Surface of the tank
5682-1	Nozzles
5682-2	Mixing, liquid distribution
5682-3	Volume/hectare adjustment system
9357	Filling, tanks content indicator
9898	Air system
13440	Residual volume of the tank
21278-1	Cleaning devices, induction hoppers
21278-2	Induction hoppers
22368-1	Internal cleaning of the tank
22368-3	General cleaning system
4012	Connecting test equipment

Table 2. *Summary of the assays' requirements*

Assay	Requirement in ISO 16119-3	Objective of the assay	Methodology used
1	5.1.1.2 "Filling"	Filling capacity of the tank with strainer	16119-3
2	5.1.1.3.1 "Residual volume"	Volume of total residual in the tank	13440
3	5.1.1.4 "Tank content indicator"	Tolerances of the indication for the tank volume	16119-3
4	5.1.1.5 "Mixing"	Concentration of mixture	5682-2
5	5.1.4 "Nozzles"	Dripping nozzles	16119-3
6	5.2.2.2 "Volume ha^{-1} adjustment system"	Volume/hectare adjustment system	5682-3
7	5.1.5 "Measuring systems"	Accuracy of the measuring systems	16122-3
8	5.3.1 "Liquid"	Distribution of liquid	5682-2
9	5.3.2 "Air"	Air flow rate of the fan	9898
10	5.3.2 "Air"	Symmetry of the air distribution	9898
11	5.4.2.1 "General cleaning system"	Tank cleaning system	22368-3
12	5.4.2.2 "Residue concentration"	Residue concentration after the cleaning system	22368-1

Arranged laboratory trials

The assays arranged (Table 2) were those required by ISO 16119-3. The methodology to be used for the laboratory trials are usually mentioned in the other complementary standards. For the assay 7, about measuring systems, no indication is specified in the ISO 16119-3. In this case, the methodology explained in ISO 15122-3 (2015) was used, centered on sprayers for bush and tree crops. The product used was always water, although in the assays 8 (mixing), 11 and 12 (cleaning system in both cases) copper oxychloride was added. Only tests 9 and 10 did not need water or other product. It was not possible to complete the trials described in the ISO 21278-1 (ISO, 2008), focused in the induction hoppers due the difficulties to find the requested product.

Results & Discussion

Complexity

Considering the requested previous time for the preparation and arrangement of all the devices and material, the time requested for a clear understanding of the methodology (some difficulties during the interpretation of the Standard happened), and the time for the tests itself, more than five labour days of two technicians was necessary to verify if the tested sprayer fulfil the Directive

Table 3. *Time needed, material and amount of water used*

Assay	Time (h/ worker)	Material	Water volume (L)
1	>1	Stopwatch	>100
2	10	Platform with an angle of 8.5º±0.5º in four directions, calibrated deposits, conduits to channel the product exiting the tank, digital inclinometer, tools	5000
3	2	Pump-tester, stopwatch	2000
4	22	Copper oxychloride, personal protective equipment, dispositive to estimate different heights of the volume of the tank, extraction pump, external battery, plastic conduits, external deposits, sample collectors, tools	2000
5	>1	Stopwatch	400
6	10	Digital external data storage system, stopwatch	3000
7	2	Electronic manual tachometer, Tape measure, Stopwatch, pump-tester, mechanical flow meter with calibrated measurement tubes, calibrated external analogue manometer according to standard EN 837-1	400
8	1	Mechanical flow meter with calibrated measurement tubes, stopwatch	400
9	2	Propeller anemometer, stopwatch, auditory protector	-
10	2	Ultrasonic anemometer 3D, computer, stopwatch, auditory protector	-
11	30	Copper oxychloride, personal protective equipment, external tanks of 1000 L, extraction pump, external battery, plastic conduits, external deposits, sample collectors, high pressure cleaner, tools	2400
12	6	Copper oxychloride, personal protective equipment, four external tanks of 1000 L, extraction pump, conduits, external battery, plastic conduits, sample collectors, tools	4100

127 applying this standard. Table 3 includes all the requested tests carried out, the time dedicated for each trial, the requested material and the quantification of the total water volume used for the purpose.

In addition it shoud be underlined the large amount of copper oxychloride needed for the tests of sprayer cleaning and agitation system evaluation, and the related environmental contamination risk and for the operator's health. These problems require specific facilities to arrange the established tests, always keeping the copper oxychloride under control.

A global balance indicates that around 88 h and 19700 L of water were used during the trials. These results emphasize, together with the material employed (Table 3), the cost and time that these tests require. In addition, in a country with water deficiency problems, such as Spain, the high volumes of water used need to be considered.

Need for a practical guideline

The arranged work demonstrated the difficulties of evaluating the sprayers following the ISO 16119-3. The assays were expensive, time-consuming and complex. A complete application of the standard may require a lot of resources. This can be a serious problem for a large number of European sprayer's manufacturers bellowing to SME group, with limited resources and facilities. Even more, another difficulty not quantified is related to the lack of knowledge of most of those medium/small sprayer's manufacturers, with great difficulty understanding all the established requirements. It is important to improve the communication and feedback from national representatives on the International Standardization Bodies and local manufacturers, in order to guarantee a clear and useful information channel. In this sense, as a requirement of the Spanish Association of Agricultural Machinery Manufacturers (ANSEMAT), UMA-UPC has developed a practical guideline (Fig. 2) with clear and practical information including real examples, in order to help the Spanish sprayer's manufactures in the complex process of the accomplishment of ISO 16119 series.

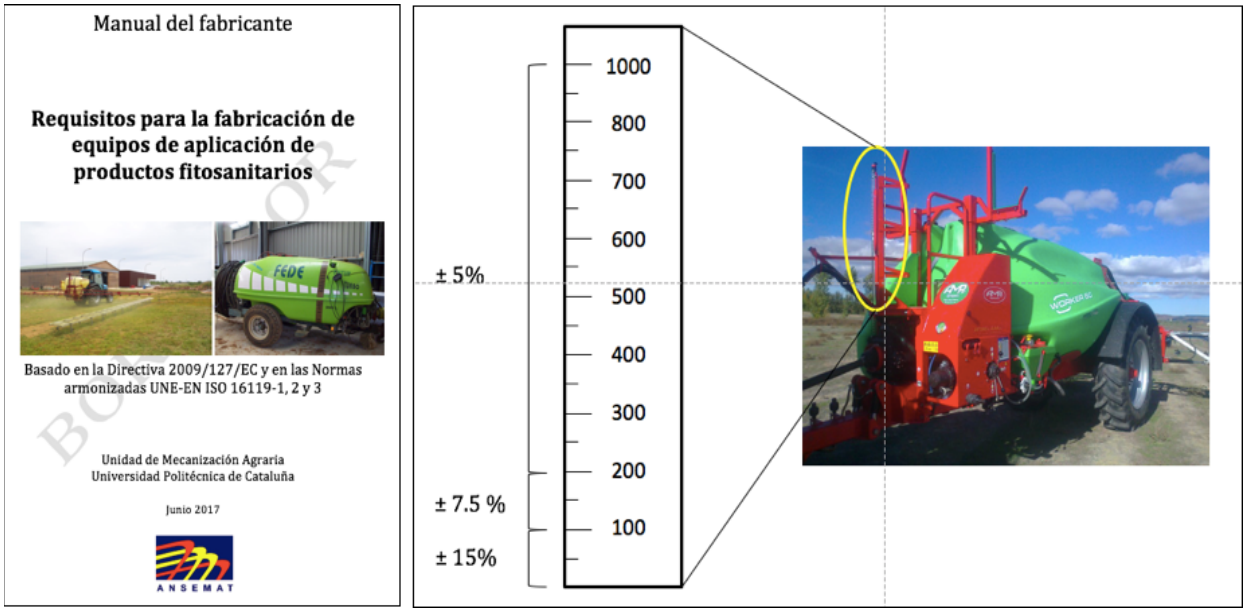

Fig. 2. Practical guideline for the application of ISO 16119 developed by UMA-UPC in collaboration with the Spanish Association of Agricultural Machinery Manufacturers/Dealers (ANSEMAT).

Conclusions

The experience demonstrated the difficulties encountered for a complete application and execution of all the tests described in ISO 16119. Considering the expertise of the research group, the complete facilities available for the purpose, the large amount of expertise's time particularly

dedicated for the task (about 88 h), has demonstrated the difficulties that SME European sprayer's manufacturers can find during the process. For these reasons, it is absolutely necessary to arrange a common support system for such a large number of EU manufacturers. And finally, an in depth review of the standard is recommended, especially for the part concerning orchard sprayers.

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