Assessment of some measurement methods for the inspection of spray application equipment

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Abstract

Several measurement methodologies used for the determination of the uniformity of the spray distribution are assessed. Nozzle adaptors used for flow rate measurements of the nozzles mounted on the sprayer cause a deviation of the measured values from the real ones, mainly in flat fan nozzles working at low pressures. According to the inspection standard, the transverse distribution uniformity in a horizontal boom sprayer can be measured in two ways. If a horizontal patternator is used, less favourable inspection results are found than if the distribution uniformity is estimated in the same conditions from the nozzle flow rate and pressure drop measurements. Finally, it was seen than the shorter overlapping length for the measurement of the boom transverse distribution established in the current standard, provide more favourable inspections compared with the overlapping length of the former one. The results of this work should be taken into account when establishing inspection procedures by the authorities and could also provide useful information for a future revision of the technical standards.

Key words: sprayer inspection, spray distribution, patternator, nozzle adaptor

1. Introduction

According to the annex II of the 2009/128/CE directive for the sustainable use of pesticides, and the corresponding methodologies established in the harmonised standard series EN ISO 16122:2015, the uniformity of the spray distribution has to be measured in a sprayer inspection.

In sprayers for bush and tree crops, this standard establishes the measurement of the nozzle flow rate and pressure drop as the only way to assess the liquid distribution uniformity. The requirements are a maximum allowed deviation from the nominal flow rate of each nozzle and a maximum pressure drop. Nozzle flow rate measurements can be made detaching the nozzles from the sprayer and measuring the flow rate of each single nozzle on a measuring bench or with the nozzles mounted on the sprayer using, if required, different kinds of nozzle adaptors to convey the liquid flow to the measuring device. In order to make measurements easier, water-tight adaptors are often used in several manual and electronic benches.

These kind of adaptors are said to cause inaccuracies in the flow rate measurement of spray nozzles. Osteroth (2007) showed that the nozzle flow rate measured with water-tight adaptors is higher than the real value in the case of air injection nozzles working at less than 10 bar. Besides, the measured error is higher with flat fan nozzles than with hollow cone nozzles.

Vanella et al. (2011) tested many flat fan and some hollow cone nozzle models with several models of water-tight adaptors and showed that the use of this kind of adaptors increased the flow rates of air induction and extended range flat fan nozzles.

On the other hand, for horizontal boom sprayers, there is also the possibility of determining the spray distribution uniformity of the booms by means of spray scan devices. They have to be build according to the requirements of the inspection standard, so that they collect the spray from the boom on 100-mm wide grooves. The coefficient of variation (CV) of the volumes collected by all the bench grooves along the overlapping length of the boom has to be lower than 10%. Besides, all the measured volume

values have to be within the ±20% interval around the average volume. It is said that the two standardized methodologies for the measurement of the spray distribution don't provide the same inspection results (Godyn et al., 2014).

The current inspection standard has also changed the measuring length for the distribution uniformity of horizontal booms, in relation to the former one, EN 13790:2003. The verification of the uniformity has to be carried out from the midpoint between the centre of the outermost nozzle and the centre of the penultimate nozzle on one side of the boom to the midpoint between the centre of the outermost nozzle and the centre of the penultimate nozzle on the other side of the boom.

The objective of this work is to assess some sprayer inspection methodologies, related with the measurement of the uniformity of the spray distribution, in the following aspects:

-To establish the error induced by the nozzle adaptors in the measurement of the flow rate

-To compare the spray distribution measurement results obtained with the use of both inspection methodologies for spray booms.

-To know the effect of the new shorter overlapping length in the measurement of the spray distribution uniformity in spray booms.

2. Methodology

2.1. Nozzles

Eleven nozzle models were chosen from four manufacturers (table 1), in order to determine the effect of the nozzle type (flat fan or hollow cone) and the air injection technology on the results of the inspection measurements.

Three different nozzle sizes were selected from each nozzle model, randomly taking four nozzle units for each combination of nozzle model and size. The flow rate for each single nozzle was measured at three different pressures on a two replication basis. The working pressures for each nozzle model were selected within the pressure range advised by the sprayer manufacturer.

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

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

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

2.2. Measuring devices

Nozzle flow rate measurements were carried out with water-tight adaptors mounted at the sprayer nozzle outlet. These adaptors are required to convey the liquid from the nozzles to the measuring device, without leaks (figure 1).The measured values were compared with those obtained with a graduated cylinder and a stopwatch, using a hose for liquid collection at the nozzle outlet.

Figure 1. Water-tight adaptors for the measurement of the nozzle flow rate (left) and horizontal patternator for the measurement of the transverse distribution in boom sprayers.

The transverse spray distribution uniformity measurements in horizontal booms were carried out with the boom placed above a horizontal patternator, built according with the requirements of the ISO 5682-2:1997 standard (figure 1). The bench has a measuring surface of 2200x3000-mm and is equipped with 50-mm-wide grooves. The collected volume in each groove in a given time is measured with an electronic system and stored in a computer file. For each combination of nozzle, pressure and working height, measurements were carried out on a two replication basis.

For every transverse distribution measurement made with the patternator, the values of the coefficient of variation (CV, %) and the deviation (D, %) of each measured volume from the mean value were computed, as indicated in the EN ISO 16122-2:2015 standard. Besides, the deviation between the measured and the nominal flow rate of every nozzle was also determined, as it was the pressure drop in the spray boom.

More information about the methodology used and the results obtained can be found in Solanelles et al., 2012 and 2016.

3. Results and discussion

3.1. Flow rate measurement with nozzle adaptors

In most cases, the use of water-tight adaptors for the measurement of the nozzle flow rate, caused a deviation of the measured values from the real ones. Significant positive deviations were measured mainly when flat fan nozzles were used (figure 2). It was clearly seen that deviations for flat fan nozzles – especially air injection nozzles – working at a lower pressure are significantly higher than those obtained at higher pressure. This trend was also noticed when air injection hollow cone nozzles were used, but not for the standard hollow cone nozzles.

According to the results, it is difficult to establish a clear pattern for the measured deviations. In general, but not in all the cases, the difference is higher when the measurements are carried out at

lower pressures. In the case of standard hollow cone nozzles, however, the deviations were not significantly affected by pressure changes. Therefore, measurements with water-tight adaptors are in general more reliable when they are carried out at the higher pressures of the nozzle working range.

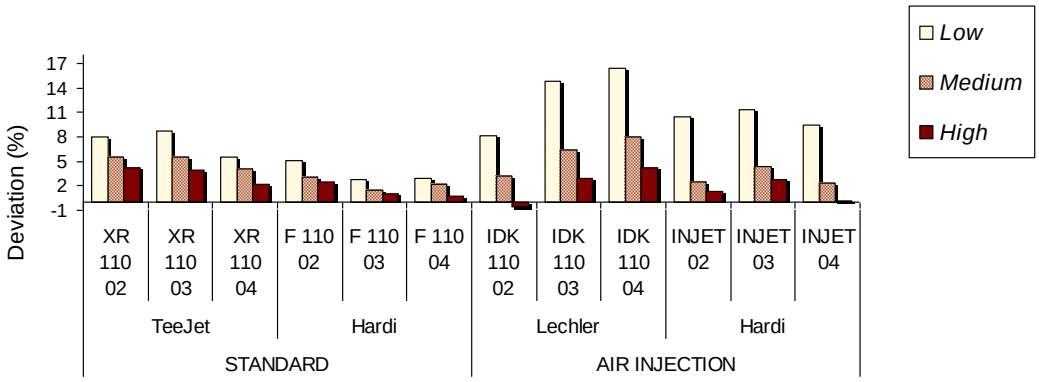

Figure 2. Deviation between the nozzle flow rate values measured with the adaptors and the real values (% of the real value), for different nozzle models at three working pressures within the corresponding pressure range for each nozzle

The possibility of a measurement error, in the case of using adaptors for nozzle flow rate measurement in the inspection of sprayers in use, should be taken into account. However, the fact that these devices have got clear advantages in relation to other methodologies, make them widely used by the inspection workshops, mainly for air-assisted sprayers. In the case of horizontal boom sprayers, hand held flow meters are also very common in use. Since they are able to collect the liquid without the use of any kind of adaptor, the error caused by the adaptor is suppressed.

3.2. Transverse distribution measurement in horizontal booms. Results with the two alternative methods

A clear difference is seen between the inspection results obtained with the two methodologies accepted in the inspection standard. In all the measurements carried out in this work, if the transverse distribution is determined from the nozzles flow rate and the pressure drop in the boom, the results of the inspection are favourable. The measured flow rates are within the ±10% interval around the nominal flow rate for every single nozzle. Besides, the pressure drop in the horizontal boom, where the nozzles were mounted, is very low, well within the 10% maximum variation required by the inspection standard.

However, if the traverse distribution is measured by means of the patternator, the values of the CV and of the deviation from the mean volume (D) lead to the fact that the inspection results are not always favourable. Therefore, the use of the patternator makes the inspection of horizontal boom sprayers more difficult to pass. In some cases, it is only the value of D that causes the inspection to fail. The different results obtained with the two methodologies should be considered when comparing the inspection results between workshops.

3.3. Transverse distribution measurement in horizontal booms. New measurement zone with the patternator according to EN ISO 16122-2:2014

If only the CV value of the measured volumes are taken into account, no significant differences are found between the inspection results obtained with the former and the current inspection standard. Nevertheless, when D values are also considered – as it is required in the inspection – the number of favourable results is significantly higher, if the overlapping length is defined according to the current inspection standard – EN ISO 16122-2:2015. Besides, with the shorter overlapping length defined in this

standard, the results of the inspection is also less affected by changes in the boom height. So, the current inspection standard makes the inspection easier to pass for horizontal boom sprayers.

In general, the nozzle working pressure has no significant effect on the number of favourable inspections, obtained from the transverse distribution measurement in horizontal booms carried out with a patternator. The fact that the working pressure does not affect the inspection result, as long as it is kept within the working range for each kind of nozzle, makes the inspection easier.

4. References

Godyn A., Holownicki R., Doruchowski G., SWIECHOWSKI, W. (2014). The comparison of the nozzle inspection methods in the field crop sprayers: Nozzle flow vs. spray traverse distribution –methodology and some results. SPISE 5. Montpellier. France. 172-174.
Osteroth, H.J. (2007). Influences of single nozzle adapters on the flow measurements results. Second European Workshop on Standardized Procedure for the Inspection of Sprayers - SPISE 2-, Straelen, April 10-12. Mitt. Biol. Bundesanst. Land-Forstwirtsch. 412: 145-148.
Solanelles, F., Tarrado, A., Camp, F., Gracia, F. (2012). Assessment of nozzle flow rate measurement methods for the inspection of sprayers in use. SPISE 4. Lana. South Tyrol. 186-190.
Solanelles, F., Camp, F., Fillat, A., Gracia, F. (2016). Assessment of the traverse distribution measurement in the inspection of horizontal boom sprayers. SPISE 6. Barcelona. 139-145.
Vanella, G., Masoud, S., Balsari, P. (2011). Effect of the nozzle adaptor of sprayer calibrator on flow rate measurements. Crop Protection 30. 1043-1047.