The effect of the type of sprayer bodies on the obtained coefficient of variation of sprayed liquid deposition

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Summary

In this work, the study results of retention uniformity of sprayed liquid deposition obtained from three kinds of nozzles mounted in sprayer bodies of various constructions were presented. For the tests, a five-spray body with a rotation axis of a spigot parallel to the sprayed surface, a three-spray body with a retention axis perpendicular to the sprayed surface and one-spray body were used. Changes in individual spraying nozzles were done by three operators. It was stated that the biggest differences in repeatability and reproducibility of adjustments were noted for five-spray bodies, however, minimum changes not exceeding the value of one percentage point were noted for single bodies. For triple bodies repeatability of obtained CV regardless of mounted nozzles changed maximum up to 1,5 percentage point and reproducibility of measurement changed from 0,5 to 0,8 percentage point.

Key words: field sprayer, sprayers periodic testing, atomizer body, coefficient of variation

Introduction

In recent years farmers benefited from supporting programs aimed mainly at farms modernization. The farms were retrofitted with necessary equipment and the old worn-out equipment was replaced with new. Therefore, a lot of agricultural sprayers were bought, often equipped very well in different devices improving, above all, security of its service and quality of performed plant protection treatment. Fiels sprayers booms were equipped with bodies in which 3 to 5 different nozzles can be mounted. Such a solution enables a fast change of the spraying nozzle suitable for given conditions and recommendations concerning plant spraying. Conditions in which agricultural spraying is done play a very essential role. Bench tests on a patternator do not reflect uniformity of liquid depositing in field conditions. Changes of the angle of the field beam setting as well its horizontal and vertical movements influence the change of uniformity of liquid deposition (Nowakowski 2007, Szewczyk 2001). Work have been done to evaluate retention uniformity of sprayed liquid deposition in settings reflecting field conditions (Ludwik and Pietrzyk 2013).

The introduced Directive 2009/128/EC of 21 October 2009 refers to rational and safe pesticides application in agriculture. Pesticides should be applied with approved equipment. According to the Ministry of Agriculture of Poland concerning periodic testing of agricultural sprayers, from 2020, testing will be carried out on electronic or manual patternators as a criterion of testing spraying uniformity (Announcement of the Ministry of Agriculture 2016, Dz. U. poz. 924, - Official Law Journal, item 924). Uniformity of sprayed liquid deposition should be tested for all sets of nozzles mounted on the spraying field beam. Uniformity of sprayed liquid deposition will have to be defined as many times as many sets of spraying nozzles are used (PN-EN ISO 16122-2:2015-07).

Research objective

The objective of the study is to check if the kind of a multi-spray body influences the obtained coefficient of variance (CV), non-uniformity of a sprayed liquid deposition after switching in the position of work for each set of nozzles mounted in the body.

Material and methods

The studies were carried out on a test-bench equipped with a field sprayer of vessel capacity of 300 l and working width of the beam 12m. The sprayer is equipped with rotodynamic pump driven electrically and an electric valve controlling the pressure and flow. The sprayer field beam of a "wet" type was equipped alternately with three kinds of spray bodies; Case A (five-spray body), Case B (three-spray body), Case C (single body). All bodies were equipped with an anti-drop membrane valve. The studies were carried out on three types of spraying nozzles: I-Nozzles with ceramic insertion Agroplast 120 04 C, II –Ejector Nozzles with ceramic insertion Agroplast 6MS 04 C, III-Ejector nozzles HYPP DDB 04. The nozzles were numerated from 1 to 24 and mounted in the sprayer bodies from the left to the right side with numbers to the back of the sprayer. The change of the type of the nozzle for testing was done by three operators: X, Y, Z. Each operator changed nozzles in simple bodies and rotated the nozzle outlet on the position of work in the case of three-spray body and five-spray body and mounted nozzles in the case of one-spray body. For each nozzle type, measurement of CV was executed and then switched on another nozzle type. For each type of nozzles three measurements were done. Measurement of non-uniformity coefficient CV was done with the use of an electronic patternator (Herbst, Spray 2000), of 2m working width and profile width of groves of the test table equalling 100 mm. Repeatability and reproducibility of work adjustments of individual kinds of nozzles were analysed assuming:

- repeatability is a variability for a given measurement adjusted several times by the same operator in a short period of time
- reproducibility is a variability of a given measurement adjusted several times by different operators in a long period of time.

The test was done at working pressure of 0,3 MPa.

For the evaluation of CV, a spreadsheet program and statistical software written in R program were used (Parafiniuk et al. 2011; Parafiniuk and Tarasińska 2013).

Results

In the first variant (Case A- five-spray body) the measurement of uniformity of sprayed liquid deposition was done for the five-spray body in which the rotation axis is parallel to the sprayed surface. Each out of three operators switched the outlets position of work for three kinds of nozzles. The test results are presented in Table 1.

Table 1 Values of coefficient of variation (CV) for nozzles mounted in case A (five-spray body).

		Case A (five-spray body)			
Nozzle	Operator	measurement 1	measurement 2	measurement 3	Average
I	X	11,9	10,1	10,4	10,8
	Y	12,1	9,2	8,5	9,9
	Z	8,3	9,2	9,5	9,0
II	X	11,1	11,6	13,1	11,9
	Y	13,7	13,8	10,6	12,7
	Z	7,9	8,1	7,1	7,7
III	X	9,9	7,9	8,3	8,7
	Y	8,1	8,5	7,4	8,0

	Z	8,1	8,3	8,7	8,4

Analysing the obtained results it can be stated that obtained CV of sprayed liquid deposition is different for each nozzle type. The highest CV was obtained by nozzles of type II, however, the lowest value of CV was obtained was also found for nozzle type II, due to operator's capability. This difference was also seen in the other nozzle types. More particularly, taking into consideration that adjustments of spraying nozzles was done by three operators (X, Y, Z), it was observed that for each nozzle type different CV values were obtained, whereas the best repeatability and reproducibility of measurement were obtained by the operator Z regardless of the kind of the nozzle set under testing. However, the biggest discrepancy of obtained results was stated for the operator Y who had the lowest repeatability of adjustments and obtained high fluctuation of CV results between the three nozzle types.

In the second variant of the study, (Case B- three-spray body), whose rotation axis is perpendicular to the sprayed surface, were mounted on the sprayer field beam. Obtained results of CV are presented in Table 2.

Table 2 Values of coefficient of variation (CV) for nozzles mounted in case B (three-spray body).

		Case B (three-spray body)			
Nozzle	Operator	measurement 1	measurement 2	measurement 3	Average
I	X	9,2	10,1	9,1	9,5
	Y	9,4	9,1	8,8	9,1
	Z	9,7	9,2	9,3	9,4
II	X	13,1	12,2	12,3	12,5
	Y	13,6	11,9	11,5	12,3
	Z	13,1	11,6	13,1	12,6
III	X	9,2	7,9	7,7	8,2
	Y	7,9	8,2	8,5	8,2
	Z	8,4	7,9	9,3	8,5

In this variant the largest CV was obtained for measurements of nozzles of type II, the minimum value of this coefficient was 11,5% and the biggest was 13,1%. For nozzle type I, the minimum value of CV was 8,8% and the maximum 10,1%. However, for nozzles of type III the minimum value of obtained CV equalled 7,7%, and maximum 9,2%. In addition, in this case none of the operators changing the spraying nozzles obtained the repeatable test result. The biggest difference in repeatability of adjustments was 1,5 percent point for the operator Z. Reproducibility obtained by individual operators was also different for each operator and fluctuated from 0,5 to 1,6 percent point.

In the third variant (Case C – single body) each operator mounted nozzles in hubcaps and put them on spigots of the bodies at the same order from the left to the right side as they were mounted in multi-spray bodies. Results of these measurements are presented in Table 3.

The highest values of CV was noted for nozzles of type I for which CV fluctuated from 7,7 to 8,5%. However, CV for nozzles of type II and III were at the similar level and values from 7,0 to 7,9% were obtained. In all cases of measurements repeatability of obtained CV did not exceed the value of 1%, however, reproducibility of adjustments by different operators was at the similar level and was from 0,2 to 0,4%.

Table 3 Values of coefficient of variation (CV) for nozzles mounted in case C (single-spray body).

		Case C (single body)			
Nozzle	Operator	measurement 1	measurement 2	measurement 3	Average
I	X	8,1	8,3	7,8	8,1
	Y	7,9	8,3	8,5	8,2
	Z	7,7	8,1	8,2	8,0
II	X	7,6	7,5	7,8	7,6
	Y	7,4	7,7	7,3	7,5
	Z	7,5	7,7	7,8	7,6
III	X	7,3	7,6	7,8	7,6
	Y	7,0	7,8	7,9	7,6
	Z	7,2	7,7	7,5	7,5

It was seen that case A (five-spray body) had the biggest differences of repeatability and reproducibility of obtained coefficient CV were noticed.

Summary

Performed tests showed that there are sizeable differences concerning repeatability and reproducibility. In this type of tests the variations depend on abilities and accuracy of the operator doing adjustments (Sawa et al 2010, Huyghebaert and Planchon 2009). The tests also showed that the multi-spray body construction affects the obtained CV results of sprayed liquid deposition. Precision of bodies' manufacturing can be the reason for systematic mistakes which influence the value of obtained CV. Not in all multi-spray bodies there is precise positioning of the nozzle outlet to the sprayed surface. The biggest observed repeatability and reproducibility of adjustments were noted in bodies with the parallel rotation axis to the sprayed surface. The bodies with the perpendicular rotation axis to the sprayed surface have the nozzle outlet placed much more precisely. The most precisely situated nozzle outlet is in single bodies but this type of body requires considerable work output and, most of all, the time needed for changing the spraying nozzle. Similar variability of obtained CV results was noted during the tests of nozzle sets with the automatic device for complex test of agricultural nozzles (Parafiniuk et al 2011).

Comparative tests of distribution of uniformity of sprayed liquid deposition obtained from the automatic device for measuring distribution from single nozzles and test of the same sets of nozzles in the laboratory conditions gave also various results of CV equalling from several to dozen or so percent points (Parafiniuk and Tarasińska 2013). To sum up, it can be stated that both a technical state of used nozzles on the field sprayer boom and precision of making sprayer bodies influence the obtained CV of sprayed liquid deposition. In special cases, in spite of mounted new accessories of the sprayer field beam, working and unworn spraying nozzles, the measurement result may oscillate at the limits of admission or disqualification of the equipment for pesticide application.

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