



The status of pesticide application equipment and the possibility of applying European standards and regulations

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Abstract

The research in this paper was conducted in the western part of the Republic of Srpska, located in the northwest of Bosnia and Herzegovina. This region is characterized by intensive agricultural production, with increasing investments in viticulture and fruit growing in recent years. As a candidate country for the accession to the European Union, Bosnia and Herzegovina must harmonize its legal regulations with the European standards. Compliance with these standards includes the introduction of legal inspection of machinery and equipment for pesticide application. The aim of the research was to collect data (brand, model, age, technical condition, etc.) on the machinery and equipment for pesticide application, as well as to gather basic data on the operators of these machines (education, basic knowledge, participation in training for safe and proper adjustment of these machines, etc.). The study was conducted as part of regular inspection activities, certification, and calibration of pesticide application equipment, which the Faculty of Agriculture performs every year before the start of the protection season. The research involved the inspection and examination of 76 pesticide application devices - sprayers. Of the total number of inspected devices, the largest deviations were recorded during the inspection of sprayers (34%), pressure gauges (16%), and pump capacity (9%).

Key words: Sprayers, Inspection, Standard, Service life, Proper operation.

Introduction

Excessive use, and often misuse, of pesticides affects environmental pollution and impairs farmers' health during pesticide application. Pesticide residues in food directly affect consumer health and increase the number of people with illnesses. In addition, food exporters must strictly and precisely adhere to standards on minimum allowable levels of residues in processed food, fresh fruit, and vegetables, as non-compliance with these standards can have catastrophic consequences, jeopardizing the country's exports and foreign exchange inflows.

According to current regulations, the agricultural policy of our country pays special attention to protecting agricultural land from pollution and to environmental protection principles. Regulations govern the economic, health, ecological, and social role of agriculture and establish measures of agricultural policy to promote sustainable agricultural production. These measures are aimed at maintaining diversity, preserving plant and animal species, soil fertility, and protecting natural conditions necessary for life in soil, water, and air.

However, in addition to weather conditions, outdated technology, poor maintenance, and amortization of pesticide application equipment are direct causes of the increasing number of treatments in agricultural production at the territory of the Republic of Srpska (Maličević, 2014).

In addition to the above, another problem in the researched area is the lack of training for farmers in safe and proper handling of pesticide application equipment. As a result, there is a higher number of farmers with symptoms of poisoning, with mild or severe consequences. Farmers with full protection equipment during pesticide application are very rare in the fields. Therefore, the number of interventions by healthcare workers in agricultural regions, especially during crop treatments, is higher.

In the EU countries, regulations on mandatory inspection of pesticide application machinery (with guidelines 2009/128/EC and 2006/42/EC) have been established as the basis of the EN 13790 standard (Banaj et al., 2014; Đokić et al., 2015; Đokić et al., 2016; Barać et al., 2017).

Directive 2009/128/EC of the European Parliament establishes a framework for implementing a National Action Plan in each country, which relates to sustainable pesticide use. One of the areas covered by the Directive directly concerns the introduction of mandatory monitoring and supervision of pesticide application machinery, mandatory training for farmers applying pesticides, and the method of treating hazardous waste. The EN13790 standard and the new ISO EN16122 relate to the method and procedures for testing pesticide application machinery for arable, viticulture, and horticultural crops (Gil E, 2006). The EU Member States are obliged to subject all pesticide

application machinery to at least one inspection by November 2016 to guarantee technical correctness (Harasta P, 2012). As a candidate country, Bosnia and Herzegovina is obliged to harmonize its regulations with the European ones, which in this part specify by whom, when, and how pesticides should be applied, and how to protect one's health and the health of consumers of these products.

Despite the list of agricultural households and agricultural machinery, the Republic of Srpska does not have records on the precise number of machines and equipment for pesticide application. In the questionnaire according to the last census, there were no data for these machines. Therefore, it is assumed that the number of these machines in the Republic of Srpska is around 20,000-25,000. However, according to research in the Republic of Srpska region and beyond, the number of machines and equipment for pesticide application is far lower. The motivation for initial research in this area includes the implementation of the current EN13790 standard, determining the necessary number of testing stations, as well as the training needed regarding proper and safe operation with plant protection machinery.

The aim of the research is to determine the condition of a certain number of machines and equipment for pesticide application and how many of them meet the standards prescribed by the European EN 13790 standard, Globalgap, and the latest EN ISO 16122.

Material and Methods

The research was conducted in the period from February to May 2023 in the northwest part of the Republic of Srpska including the areas of the following municipalities: Prijedor, Novi Grad, Kozarska Dubica, and Gradiška. It was carried out as part of regular activities focusing on control, certification, and calibration of pesticide application devices, which the Faculty of Agriculture performs before the beginning of the protection season. The research was realized in two segments, an oral part using questionnaires and a technical part by measuring the control and proper operation of the application devices. Part of the research conducted using questionnaires included questions divided into several groups:

- a) general information about the operator of the unit,
- b) general information about pesticide application machines,
- c) visual and operational defects of machines,
- d) defects determined by measurement using equipment.

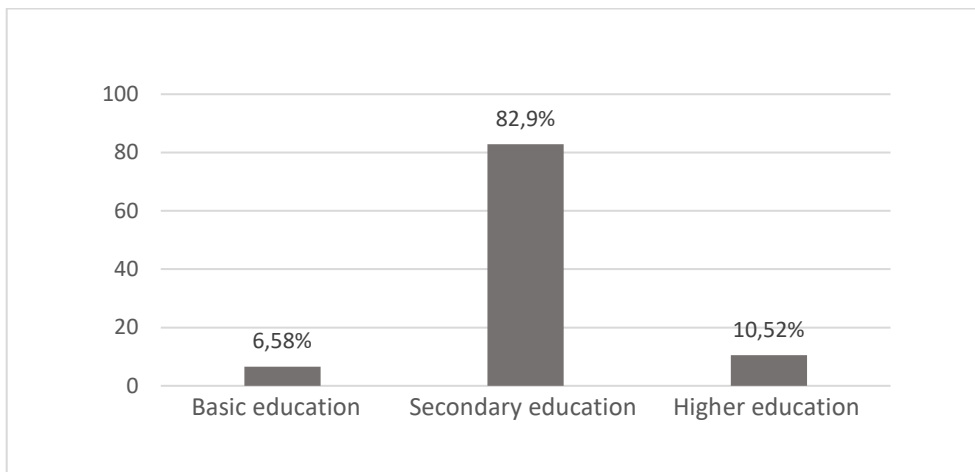
The measuring equipment "AAMS-SALVARANI" was used for testing. Instruments used to test the proper operation of devices were as follows: the pump capacity meter, nozzle capacity meter, manometer, stopwatch, and non-

contact rpm meter for a tractor PTO shaft. The control of the number of rotations of the PTO shaft and the condition of the cardan shaft was performed. The PTO shaft was the first step in the aforementioned test, as it was visually inspected to determine if the devices had appropriate protective covering, proper lubrication, and if they were correctly positioned. The manometer test involves the comparison of the pressure readings on a device manometer with a calibrated reference manometer. In addition to the pump, it is crucial to check the proper operation of nozzles since their functionality significantly affects the quality of the application.

Results and Discussion

The paper presents an analysis of inspection results on pesticide application equipment conducted in the western part of the Republic of Srpska. The research was carried out in accordance with the European standards prescribing methods and equipment for conducting inspections. Proper operation of the device, especially the condition of the nozzles, has a crucial impact on the quality of the application. It is certain that chemical methods of protection will continue to be used in the future, so pesticides should be used more rationally, with the aim to reduce both the amount of chemicals applied and the number of treatments. Previous research has shown the opposite, i.e., frequent infections require a large number of treatments per year, sometimes even over 20 times during the growing season (Maličević, 2010). Adjusting pesticide use while ensuring effectiveness can be achieved by increasing the precision of devices (Maličević, 2012). Proper adjustment of devices increases quality and efficiency, which is manifested in better deposition of the substance and uniform application, thus preventing inadequate and increased pesticide use (Višacki, 2015). In addition to the aspects mentioned above, an important segment to be considered in regards with treatment is the proficiency of a device operator, considering that today's preparations are more biologically active. Proficiency refers to the level of professional qualification in terms of possessing prior knowledge in handling traction drive units equipped with software for guidance and monitoring of operational parameters.

Graph 1 shows data on the operators of application units in terms of possessing general knowledge, or professional qualification, which provide the basis for understanding the mutual influence of physical properties. According to the data presented, it can be concluded that out of the total number of the operators under survey, 6.58% of them have had basic education, the majority have had secondary education 82.90%, and 10.52% have had higher education.



Graph. 1 Education of application device operators

It is particularly concerning that all operators included in the research have not attended training on the safe and proper operation of pesticide application equipment. When asked about adjustments crucial for effective and quality protection, the majority provided incorrect answers. A similar situation has been recorded for Serbia, as the use of pesticides is further complicated due to the lack of operational machine testing and often inadequate training for operators (Sedlar, 2007). The conclusion is that the pesticide application equipment is adjusted and used based on personal experience and information shared by friends. In many cases, it has been found that this knowledge is insufficient and often incorrect. The operating principle is based on physical processes of liquid disintegration and distribution, making it crucial to understand the influence of physical variables such as pressure and flow on the quality of effective protection.

All survey participants agreed that there was a need to organize such training in order to expand their knowledge in regards with the exploitation of pesticide application equipment.

After completing such training, they were aware that they could significantly contribute to raising pesticide application to a higher level. This would result in cost reduction during plant protection procedures, protection of their health, and reduction of environmental pollution. Table 1 shows machine brands that are most represented in the area covered by the research.

Tab. 1 Status of application devices in terms of manufacturer and year of operation

No	Manufacturer	Total/%	Years of operation			
			0-5	5-10	10-20	20+
1.	Agromehanika Kranj	27 (35.52)	6	15	5	1
2.	Morava	16 (21.05)	3	2	9	2
3.	Mitterer	12 (15.80)	2	8	2	0
4.	Munckhof B.V.	18 (23.69)	3	11	4	0
5.	Vreček Kranj	2 (2.63)	0	1	1	0
6.	Evrotech	1 (1.31)	0	1	0	0
TOTAL		76 (100)	14	38	21	3

According to the data shown in Table 1, the most represented brand of application devices was Agromehanika Kranj with 27 units, accounting for 35.52% of the total. Encouragingly, only three devices, or 3.94%, were over 20 years old. In addition, devices being used between 10-20 years amounted to 27.63%, while devices with service life between 5-10 years made up 50.00% (38 devices). There were 14 devices recorded with less than five years of service life, thus indicating a poor financial situation agricultural producers have been dealing with despite the existence of incentives for renewing agricultural machinery. It can be assumed that the situation has improved, given that government measures for capital investments were implemented in the previous year, providing significant funds for the acquisition of new agricultural machinery.

Considering that these are devices used in food production and have been in operation for a long period, it is essential to continually conduct inspections and calibrations to monitor their proper operation and functionality. The results presented in Table 2, obtained through the inspection of nozzle capacity and other components crucial for the quality of application, have confirmed the significance of this approach.

Increasing the areas under vineyard and fruit tree cultivation has contributed to the increased number of towed tractor sprayers, with 72 (94.73%) of the controlled devices being of towed design.

The results obtained during the inspection of the application devices, both by measurement and visually, are presented in Table 2. According to the results, it can be concluded that after the visual inspection of the devices, the highest number of deficiencies and modifications was recorded due to the lack of protective covering on the cardan shaft, which could be very dangerous during device operation (27.63%). Other visually identified modifications related to the table for nozzles 15 (19.74%), filters 11 (14.46%), and tank scales 5 (6.58%).

Among the total number of deficiencies and modifications, visual deficiencies most commonly included various adaptations of nozzle fittings, tank repairs, broken valve handles, leaks at joints, broken or repaired tank lids, and chassis reinforcement due to bending and breaking.

Tab. 2 Deviations recorded for pesticide application devices

Assembly of the tested device:	Deficiencies identified during the inspection of application devices:			
	Functioning properly (%)	Minor deviation (%)	Major deviation (%)	Malfunctioning (%)
Manometer	48 (63.16)	10 (13.16)	13 (17.11)	5 (6.58)
Nozzles	42 (55.26)	17 (22.37)	14 (18.43)	3 (3.94)
Pump	53 (69.74)	15 (19.73)	7 (9.22)	1 (1.31)
Fan	73 (96.06)	3 (3.94)	/	/
Control handles - valves	72 (94.74)	4 (5.26)	/	/
Pressure regulator	73 (96.06)	/	/	3 (3.94)
Stable construction	74 (97.37)	2 (2.63)	/	/
Joints	70 (92.10)	/	6 (7.89)	/
Mixing mechanism	62 (81.57)	13 (17.11)	/	1 (1.31)
Scale on the tank	67 (88.16)	5 (6.58)	/	4 (5.26)
Filters	65 (85.52)	8 (10.52)	3 (3.94)	/
Tank	75 (98.68)	1 (1.31)	/	/
PTO shaft	64 (84.21)	21 (27.63)	/	/
Table for nozzles	61 (80.26)	/	15 (19.74)	/
Wheels	74 (97.37)	2 (2.63)	/	/

The inspection of the technical condition of the devices, crucial for the quality of application, as shown in Table 2, indicates that most deviations have been observed during the inspection of nozzle capacity, namely 34 (44.74%). Nozzles are the most important component of the pesticide application equipment, ensuring the appropriate flow and adequate spray formation (Tadić et al., 2014). Sprayers are often clogged with mechanical impurities, due to poor water quality and wear and tear from extended periods of use (Đokić et al., 2018).

The lifespan and proper maintenance significantly affect the functionality of the pump, often referred to as the heart of the device. During the research, 15 devices (19.73%) were found to have had minor deviations of the pump, indicating reduced capacity but within acceptable limits, while for seven devices (9.22%), the condition of the pump requiring repair was identified, with one device having a faulty pump. The importance of the pump lies in ensuring the necessary liquid volume for both the nozzles and solution mixing. The

operational status of the machines involves checking the proper operation of the pressure gauge, with 13 devices (17.11%) showing major deviations and five devices (6.58%) having faulty pressure gauges (broken glass, missing needles, and one machine lacking a measuring instrument). It should be noted that the proper operation of the pressure gauge significantly affects the quality of the application, reflected in the nozzle capacity and droplet size, as well as the coverage of the target surface. Furthermore, higher pressure in the system often causes hose rupture and shortens the operational lifespan (Declercq, et al., 2013).

The research on visual and operational technical deficiencies of the pesticide application equipment in the area under the survey has shown that a large number of machines did not meet the increasingly stringent conditions dictated by the prescribed standards, especially those specified in the latest EN ISO 16122. It is assumed that the use of non-original parts in the surveyed area has led to frequent breakdowns and deviations during the operation of the application devices.

In the Republic of Srpska, inspecting pesticide application equipment is not a legal obligation. However, the "Regulation on the Method and Periodicity of Control Testing of Devices for the Application of Plant Protection Products," which came into force in 2015, stipulates that devices must be inspected at least once, no later than 31 December 2016, and subsequently undergo regular inspection at least once every three years (Article 3, paragraph 2).

Field studies have shown that machine operators usually adjust and maintain the machines themselves. The survey conducted in this research has indicated that machine operators have often provided incorrect answers to various questions regarding the adjustment and maintenance of the machines. Therefore, it would be necessary to organize training for the safe and proper operation of these machines.

The inspection showed that non-original spare parts were mostly used, especially in older devices. Additionally, machine storage and maintenance were often carried out under inappropriate conditions, reducing the operational lifespan of the machines. These procedures significantly affect the condition of the machines, unsafe operation, poor work quality, and increased environmental pollution.

Conclusion

The most represented brand of pesticide application equipment in the area under study was Agromehanika Kranj with 27 units, accounting for 35.52% of the total. According to the research results, it can be concluded that the biggest problem during visual inspection was the lack of covering on the cardan shaft (27.63%), followed by the table for nozzles - 15 (19.74%), filters - 11 (14.46%), and tank scale - five (6.58%). Regarding technical deficiencies, it can be

observed that most irregularities were found during the inspection of nozzles 34 (44.74%). The inspection of proper operation of the pressure gauge has shown that major deviations were recorded in 13 devices (17.11%), while five devices (6.58%) had faulty pressure gauges. During the inspection of pump capacity, 15 devices (19.73%) were found with minor deviations, implying reduced capacity within permissible limits. However, for seven devices (9.22%), the pumps requiring repair were identified, with one device having a faulty pump. The field investigations have shown that the machine operators usually adjusted and maintained the machines by themselves. The survey indicates that the operators often provided incorrect answers to various questions regarding the adjustment and maintenance of machines. Hence, it follows that it would be necessary to organize training for the safe and proper operation of these machines. Another problem is the fact that mostly non-original (aftermarket) spare parts have been used, especially in older devices. Additionally, machine storage and maintenance were often carried out under inappropriate conditions, thus reducing the operational lifespan of the machines. These procedures significantly affect the condition of the machines, unsafe operation, poor work quality, and increased environmental pollution.

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Стање уређаја за апликацију пестицида и могућности примјене европских стандарда и норматива

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Сажетак

Истраживања у овом раду спроведена су у западном дијелу Републике Српске. Регион се налази на сјеверозападу Босне и Херцеговине. У овом региону одвија се интензивна пољопривредна производња, а у последње вријеме све више се улаже у виноградарство и воћарство. Босна и Херцеговина као земља кандидат за улазак у Европску унију мора прилагодити своје законске прописе са европским. Стандард подразумијева поред осталог и увођење законске инспекције машина и опреме за апликацију пестицида. Циљ истраживања био је прикупљање података о (марка, модел, старост, техничка исправност и сл.) машинама и опреми за апликацију пестицида као и прикупљање основних података о руковаоцима ових машина (образовање, основна предзнања као и присуство на обуци за безбједно и правилно подешавање ових машина и сл.). Наведено испитивање проведене у склопу редовне активности контроле, атестирања и калибрације уређаја за апликацију пестицида, које Пољопривредни факултет сваку годину врши пред почетак сезоне заштите. Истраживање обухвата контролу и преглед 76 уређаја за апликацију пестицида-орошивача. Од укупног броја прегледаних уређаја највећа одступања су евидентирана при контроли распрскивача (34%), маноматара (16%) и капацитета пумпе (9%).

Кључне ријечи: орошивачи, контрола, стандард, период експлоатације, техничка исправност.

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