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ISAE 2019

Belgrade, Serbia

31.October - 2.November 2019

Univerzitet u Beogradu - Poljoprivredni fakultet

IV MEĐUNARODNI SIMPOZIJUM O POLJOPRIVREDNOJ TEHNICI

(The Fourth International Symposium on Agricurtural Engineering)

"ISAE 2019 - Proceedings"

Urednici/Editors:

Dr Aleksandra Dimitrijević
Dr Ivan Zlatanović

Izdavač: Univerzitet u Beogradu – Poljoprivredni fakultet

Za izdavača: prof. dr Dušan Živković

Glavni i odgovorni urednik: prof. dr Radojka Maletić

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Štampa: Digitec d.o.o., Vojvode Stepe 337, Beograd, Srbija

Izdanje: Prvo

Tiraž: 100 primeraka

Beograd 2019

CIP- Каталогизација у публикацији
Народна библиотека Србије

631.3(082)(0.034.2)
631.17(082)(0.034.2)

INTERNATIONAL Symposium on Agricultural Engineering (4 ; 2019 ; Beograd)
Proceedings [Elektronski izvor] / The Fouth International Symposium on Agricultural Engineering ISAE 2019, 21. October - 2. November 2019, Belgrade, Serbia ; [organizer] University of Belgrade, Faculty of Agriculture, The Institute for Agricurtural Engineering ; co-organizers University of Basilicata, School for Agricultural, Forestry, food and Environmental Sciences, Potenza, Italy ... [et al.] ; [editors Aleksandra Dimitrijević, Ivan Zlatanović]. - 1. izd. - Beograd : Univerzitet, Poljoprivredni fakultet, 2019 (Beograd : Digitec). - 1 elektronski optički disk (CD-ROM) ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 100. - Bibliografija uz svaki rad.

ISBN 978-86-7834-342-1

а) Пољопривредне машине -- Зборници б) Пољопривреда -- Механизација -- Зборници

COBISS.SR-ID 281928972

The Fourth International Symposium on
Agricultural Engineering
ISAE-2019

31st October-2nd November 2019, Belgrade – Zemun, SERBIA
http://www.isae.agrif.bg.ac.rs

Organizer:
University of Belgrade, Faculty of Agriculture, Department for Agricultural Engineering, Belgrade, Serbia.

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ISAE-2019
PROCEEDINGS

ISAE 2019
4th International Symposium Agricultural Engineering
Belgrade, Serbia
31.October - 2.November 2019

TECHNICAL ACCURACY OF ORCHARD SPRAYER USED IN INTENSIVE FRUIT AND VINEYARD PRODUCTION IN REPUBLIC OF SERBIA

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Abstract: *The technical accuracy of the machine is a prerequisite for the effective implementation of chemical protection in fruit and grapevine production. The paper presents the results obtained during the control testing of 50 different models of orchard sprayers, with different period of exploitation in growers throughout Serbia that are used in intensive fruit and grapevine production. During the control testing, a large number of parameters were monitored, using standardized methods and test procedures. Comparison of the obtained data was applied to four groups of orchard sprayers (defined by the period of the exploitation). The technical accuracy of the individual orchard sprayer is expressed by the coefficient of the technical correctness (C_{ta}) according to individual marks of the tested parameters of orchard sprayers.*
Out of the total number of investigated orchard sprayers, 12% of the orchard sprayers are in exploitation for less than three years, while the largest number of orchard sprayers, and 42% is in exploitation for seven years or more. The technical accuracy of Group 1 orchard sprayers was sufficiently high, except for the parameters related to the Measuring regulatory system (C_{ta} = 0.80) and the Nozzles (C_{ta} = 0.86). In Group 2, a decrease in the coefficient of technical accuracy in all parameters was observed with respect to the sprayers from Group 1, which was particularly pronounced for Agitators (C_{ta} = 0.50) and Nozzles (C_{ta} = 0.68). The orchard sprayers from Group 3 are characterized by a low coefficient of technical accuracy for the Nozzles (C_{ta} = 0.37), while Group 4 orchard sprayers have a very low coefficient of technical accuracy in all tested parameters. The level of technical accuracy of the orchard sprayers used in intensive fruit and grapevine production is directly dependent on the period of their exploitation.

Keywords: *control testing, coefficient of technical accuracy, period of exploitation, maintenance of the orchard sprayers, application quality*

1. INTRODUCRION

Proper technical functionality of plant protection machines is a prerequisite for carrying out efficient operations, achieve financial savings and increase safety among the employees. In order to provide the production of healthy food, as well to protect the environment, controlled use of pesticides should be ensured. To ensure this kind of pesticide application, proper machinery is needed during the exploitation period.

Modern agricultural production involves the increased use of pesticides as plant protection products, as well as the use of pesticide application machines [8]. The proper setting of the device for the application and the adequate use of the treatment aggregate have a significant impact on the quality and efficiency of the application of the pesticides. The amount of costs depends on the choice of the machine and its performance, and the amount of costs directly affects the cost of production. The use of modern machinery combined with the optimum technique for the application, which has significantly advanced, increases the efficiency, cost-effectiveness and the safety of the environment. For all the above reasons, the pesticide application technique is nowadays a major plant protection issue.

The introduction of the mandatory "HACCP" standard in the food industry, as well as the "GLOBALGAP" standard in primary agricultural production ensure, to some extent, production of health-safe food and the absence of pesticide residues. Farmers cannot obtain the certificates for the "HACCP" and GLOBALGAP" if there is no information showing how the application of pesticides was carried out during the entire production process. The aforementioned standards require periodic monitoring of the proper technical functionality of the plant protection machinery. The testing of the machines is carried out according to the European standard EN13790, which has been in force since 2003 and is divided into prEN 13790 - 1 related to field sprayers and prEN 13790 - 2 standard for orchard sprayers (atomizers) [5]. These standards contain a set of rules and guidelines for determining the safety and technical functionality of plant protection machinery.

The first testing of plant protection machines in the Republic of Serbia was carried out in 2006 and at the time very poor results of the flow of the nozzles were obtained due to inadequate maintenance [6]. There are more and more agricultural areas in Serbia and therefore the usage of plant protection machines is bigger. Control testing of plant protection machines in Serbia is not regulated by law yet, but all larger companies and agricultural holdings are conducting these tests in order to get a technical functionality certificate of the machines, as well as to identify malfunctions that are not noticeable. Regular control of a plant protection machinery condition is a necessary measure in modern agricultural production, which uses pesticides over a large area [6].

In our field research we found that the defective nozzles were the biggest problem for the proper operation of plant protection machines. In the field, nozzles are often clogged with mechanical impurities, poor water quality or deterioration due to a long period of exploitation, which significantly affects the quality of pesticide application. In addition to regular maintenance and cleaning, it is also necessary to perform regular checks of the proper operation of the nozzles on the tested plant

protection machines. The flow rate of the spray liquid depends on the condition of the nozzle, the pump flow, the condition and the methods of maintaining the nozzle [4].

2. MATERIAL AND METHOD

The survey was conducted on five agricultural holdings in the Republic of Serbia, where the data collected were obtained by controlling technical equipment of the orchard sprayer. The holdings on which the survey was conducted have an average of 50 ha of fruit and wine production. In order to perform correctly control of technical functionality, the equipment for control testing of plant protection machines, owned by the Faculty of Agriculture in Belgrade, was used. The pump capacity was measured using the "AAMS Pump tester", while the pressure gauge functionality was checked with the "AAMS Manometer tester". Testing the flow rate of each individual nozzle was performed using an "AAMS Flow rate device". During the functionality check of the working parts of the orchard sprayer the questionnaire was filled in, which consisted of four parts. The first part was related to the general information about the orchard sprayers (type, model, date and year of production). The second part of the questionnaire included information on the condition of the protective lining (safety), filters, fans, agitators, tanks, leakage (dynamic and static), condition of conduits and hoses. The third part of the questionnaire consisted of pressure gauge and pump flow data. Also, the third part of the questionnaire contained the data of the declared pump flow, which are read from the plate carved on the pump. The fourth part of the questionnaire referred to the data on the established flow of the nozzles, as well as the data on their factory declared flows which are read from the nozzle manufacturers catalog.

After collecting the data and completing the questionnaire, the processing of the data was carried out. A form consisted of controlled elements of the orchard sprayer and the coefficients of technical functionality was created. The assessment of the technical functionality of the tested elements was made on the basis of the questionnaire data, where the score values have the following meaning:

- C_{ta} = 0 – 0,2 - completely out of order orchard sprayer parts, it is necessary to replace the tested elements with new ones;
- C_{ta} = 0,2 – 0,4 - the orchard sprayer elements are out of order but they can be repaired;
- C_{ta} = 0,4 – 0,6 - the elements of the orchard sprayer are within acceptable functionality limits;
- C_{ta} = 0,6 – 0,8 - the elements of the orchard sprayer are functional, but there are some slight irregularities in the operation of the orchard sprayer, which are easily repaired;

41 orchard sprayers with different models and technical characteristics were tested. In order to facilitate the processing of the data and organize them, the tested orchard sprayers were divided into four groups according to the influence of the exploitation period:

- Group 1: 0 to 1,99 years;

- Group 2: 2 to 3,99 years;
- Group 3: 4 to 6,99 years old;
- Group 4: 7 years and older.

Fig. 1 Division of tested orchard sprayers according to the impact of the exploitation period

3. RESEARCH RESULTS AND DISCUSSION

The technical functionality of the orchard sprayer has a decisive influence on the proper distribution of the protective liquid, as well as on the chemical protection of orchards and vineyards. During the testing of the technical functionality of the orchard sprayer it was found that, despite the calibration, there was a change in the functionality of the elements of the orchard sprayer during the exploitation period. The obtained results show that irregularities in the operation of the elements of the orchard sprayer were caused during the exploitation period. It was found that Group 4 had a lower coefficient of technical functionality of the tested orchard sprayer elements compared to Group 1.

Table 1 Display of technical functionality score coefficients according to tested elements of the orchard sprayer

Group	Period of exploitation	Power take-off	Leaks	Pumps	The agitator	Tank	Pressure gauges	Hoses	Filters	Nozzles	Fans
1	1	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1.00	0.86	0.96
2	2.2	0.66	0.78	0.76	0.50	0.69	0.66	0.95	0.86	0.68	1.00
3	4	0.42	0.76	0.76	0.61	0.82	0.68	1.00	0.96	0.37	0.94
4	12.24	0.12	0.39	0.49	0.50	0.61	0.38	0.75	0.71	0.34	0.61

The tested elements of the orchard sprayer Group 1 have a score coefficient of technical functionality from C_{ta}=0.86 to C_{ta}=1.00. Average ratings for Group 1 of technical functionality of tested orchard sprayer elements show that all elements are in order (Table 1). The good results of the technical functionality of tested orchard sprayer elements of Group 1 result from their average period of exploitation of one year.

Group 2 whose average period of exploitation is 2.2 years, has oscillations in the evaluation of the technical functionality of the tested orchard sprayer elements. In Group 2 the coefficient of technical functionality for fans is C_{ta}=1 and for conduits and hoses C_{ta}=0.95 which makes these elements operational and functional. The agitator, as one of the essential elements of the orchard sprayer, within the Group 2 have a coefficient of technical functionality C_{ta}=0.50. Operational functionality of the agitator in Group 2 decreases by 50% compared to Group 1.

The tested orchard sprayers within Group 3 have an average exploitation period of 4 years. Orchard sprayer elements with the lowest technical functionality score within Group 3 are nozzles (C_{ta}=0.37) and power take off (protective lining on power take off C_{ta}=0.42). Such a low technical functionality coefficient stems from the length of the exploitation period.

The fans (C_{ta}=0,94), conduits (C_{ta}=1) and filters (C_{ta}=0,96) have a significantly higher technical functionality coefficient score. Fans, conduits and filters are made of more durable materials, so an average operating life of 4 years does not affect their functionality and operationality. Fans, conduits and filters are made of more durable materials so an average exploitation period of 4 years does not affect their functionality and operationality.

Orchard sprayer elements from Group 4 that have been subjected to control testing have an average exploitation period of 12.24 years. In Group 4, all tested orchard sprayer elements have a decreasing coefficient of technical functionality. Power take off (C_{ta}=0.12), nozzles (C_{ta}=0.34) and leaks (C_{ta}=0.39) have the lowest technical functionality score. Slightly better technical functionality scores were recorded for conduits and hoses (Cta=0,75) and filters (Cta=0,71). The assessment of technical functionality of orchard sprayer elements which has not been changed during the 4 years of exploitation begins to change in Group 4.

The elements of the orchard sprayer on which depends proper application of the protective fluid are the pump, pressure gauges, nozzles and the agitators. In this study, it was observed that agitators during the exploitation period had a decrease in technical functionality coefficient score. For an average exploitation period of 12.24 years, the agitator technical functionality coefficient is Cta = 0.50.

It is this decline of technical functionality coefficient that shows the significance of the influence of the period of exploitation on the functionality of the agitator. Also, a decrease in the technical functionality coefficient during the period of exploitation was also noted with pumps (C_{ta} ranges from 1.00 in Group 1 to 0.49 in Group 4). The flow rate of the tested nozzles during the exploitation period changes from the one declared at the factory, as can be seen in Figure 2. The nozzle technical functionality coefficient ranges from C_{ta} = 0.86 in the first year of exploitation and C_{ta} = 0.34 in the average exploitation period of 12.24 years. A decrease in the pressure gauges technical functionality coefficient was noted. The pressure gauge in the first year of exploitation

has C_{ta}=0.80 and C_{ta} = 0.36 with an average exploitation period of 12.24 years. The displayed values of the pressure gauges technical functionality coefficient shows that during the exploitation period pressure is displayed, which is bigger or smaller than the given one.

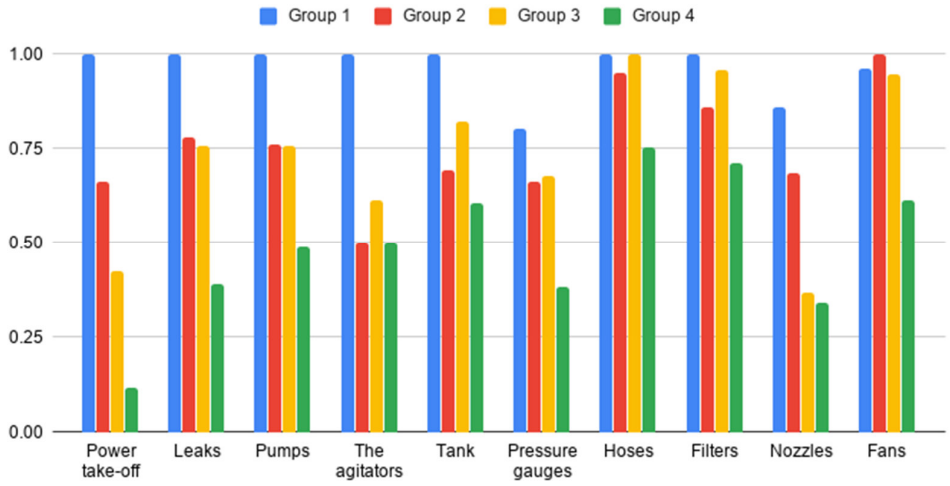

Fig. 2 Display of assessment of tested orchard sprayer elements technical functionality by groups

The orchard sprayer elements that have the biggest changes in the assessment of technical functionality during the period of exploitation are power take offs (C_{ta} from 1.00 in Group 1 to 0.12 in Group 4). The protective lining on power take off has extensive damage during the period of use. Damage on the power take off protection is the consequence due to the length of exploitation. The material of which the protective lining for the power take off is made, begins to wear out during the period of exploitation, so it is necessary to check its entirety regularly. Leakage occurring on the orchard sprayers increases during the exploitation period (at the beginning of exploitation the value is Cta = 1.00, and then decreases to Cta = 0.39), (Figure 2).

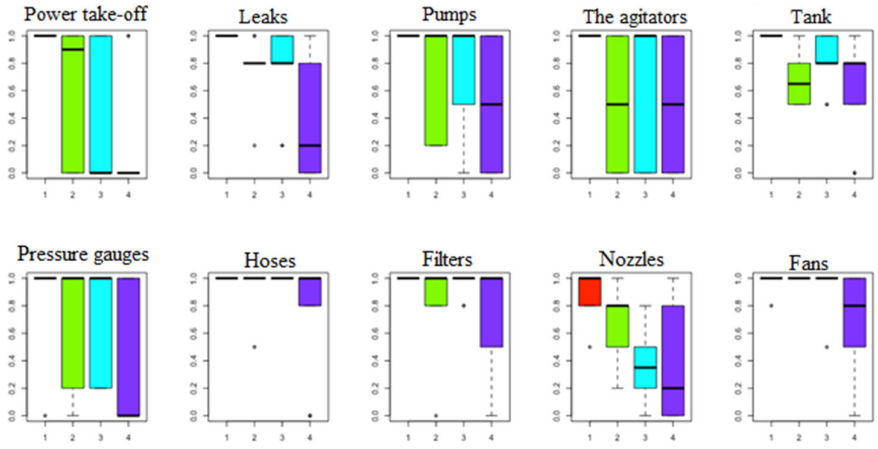

Fig. 3 Effect of exploitation period on the tested orchard sprayer elements technical functionality

The tested orchard sprayer elements showed that there is an influence of the exploitation period on their technical functionality. The functionality of the tested elements decreases with the period of exploitation (from year to year coefficient of technical functionality is lower). However, there are those orchard sprayer elements that have started to break down in Group 4 (average exploitation period of 12.24 years). Fans, filters and conduits during testing showed changes in functionality and operation only in Group 4 (Figure 3). The fans have been fully operational for 4 years of exploitation (C_{ta} of 1.00 for Group 1, while for Group 3 C_{ta} it is 0.94), while for Group 4 (average period of exploitation of 12.24 years) the coefficient score decreases to $C_{ta} = 0.61$.

In the case of conduits and hoses, we also have a decrease in the technical functionality coefficient score only in Group 4 (average exploitation period of 12.24 years) to Cta = 0.75. Figure 3 shows that fans, conduits and filters require regular annual controls to maintain them throughout the period of exploitation.

4. CONCLUSION

Republic of Serbia has not yet adopted the law EN 13790, which obliges all agricultural producers to regularly check plant protection machinery so that they can market their products. However, in the Republic of Serbia there are stations that control plant protection machinery and there are already a large number of producers that have tested their plant protection machinery. However, there are also producers who have not yet heard of this type of testing.

This research has shown that the exploitation period has an impact on 72% of the tested orchard sprayer elements. During this research major irregularities were noted with the pumps, agitators, nozzles and pressure gauges in Group 4, that is, for the orchard sprayers with the longest period of exploitation. During the exploitation of the orchard

sprayers, material from which the elements are made wears out. Significant wear out of the orchard sprayers elements was noted with nozzles and pumps. The flow of the nozzles deviates from the factory declared flow, because blockages are created in the body of nozzles or there is an expansion of the protective fluid leakage hole. The tested pumps had a flow deviation from the factory declared flow due to the wear out of the membrane during the exploitation period which led to its bursting. The aforementioned facts show a great need for regular orchard sprayer technical functionality control during exploitation.

With the introduction of mandatory plant protection machinery control testing, all producers would have to test plant protection machinery once a year by authorized persons, if this were supplemented by the introduction of other laws on the use of pesticides, irregularities in their use would drastically decrease, thereby this would increase environmental protection from the harmful effects of pesticides, which directly affects human health. This law would, in addition to all of the above, have the effect of reducing malfunctions of plant protection machinery during exploitation and, consequently, reducing the cost to producers.

REFERENCES

1. Declercq, J., Huyghebaert, B., Nuyttens, D. (2012) An overview of the defects on tested orchard sprayers in Belgium, Fourth European Workshop on Standardised Prodedure for the Inspection of Sprayers – SPISE, pp. 180-185.
2. Dimitrovski, Z. (2017) INSPECTION OF PESTICIDE APPLICATION EQUIPMENT, of Agriculture and Plant Sciences, JAPS, 15(1-2) pp. 37.
3. Dimitrovski, Z., Dimitrov, S., Kukutanov, R. (2017) CONDITION OF AIR ASSISTED SPRAYERS IN STIP REGION AND POSSIBILITY OF APPLYING EUROPEAN STANDARD EN 13790, Journal of Agriculture and Plant Sciences, JAPS, 15(1-2) pp. 45.
4. Đukić, N., Sedlar, A., Bugarin, R. (2005) Značaj redovne kontrole prskalica. Revija „Agronomska saznanja“, 15(4) pp. 18-20.
5. Ministarstvo poljoprivrede i zaštite životne sredine: Priručnik za sprovođenje kontrolnog tetiranja prskalica i orošivača, Beograd, (2015).
6. Sedlar, A., Đukić, N., Bugarin, R. (2007) Prve inspekcije orošivača u Srbiji. Savremena poljoprivredna tehnika, broj 3 – 4, pp. 12 – 19.
7. SVENNSSON, S.A. (2004) Experiences of introducing an inspection system for orchard sprayers in Sweden, First Europe Workshop on Standardised Procedure for the Inspection of Sprayers in Europe — SPISE —, Braunschweig, pp. 111-113.
8. Urošević, M., Dimitrijević, A. (2016) Mašine za primenu pesticida, Poljoprivredni fakultet Beograd.