

The Influence of the Sprayer Control on the Increase in the Productivity of the Machine-Tractor Aggregate in the Protection of Orchards

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Abstract

For the chemical protection of orchards, a research on the surface area of 150 ha was carried out, and a method of spraying was applied. In this method, machines known as orchard sprayer are used, in which, in the presence of the produced air current, liquid disintegration is also carried out at a drop size of 50 to 150 μm . The aim of the research is to improve the precision of work within the control of the device, where the emphasis on the nozzle capacity is primarily augmented, and therefore increases the productivity of the device. The results obtained on the basis of a 10-hour working time prove that the exploitation of the controlled orchard sprayer ensures greater productivity by 2.24 ha on a plot distanced 50 m from the location of the tank refill, i.e., 2.20 ha on a plot distanced 2000 m from the location of the tank refill, for the drawn sprayer of 1.000 l volume. By analyzing the total energy inputs of orchard protection, different application models point to a smaller energy input when using controlled devices on a 50 m range for 7.58%. Energy inputs on a longer distance plot are by 24.68% lower in favor of the treatment of controlled sprayer.

Key words: apple orchards, applications, sprayer, exploitation parameters

Introduction

Fruit production is a significant branch of agriculture in the Republic of Srpska, with production areas in all parts. Raising and cultivating orchards requires significant resources, but also provides significant financial gain.

The biggest problem for our producers is competitiveness in the market, or a small percentage of production incentives, which greatly affects the competitiveness. Taking this into account, it follows that the agriculture of the Republic of Srpska and Bosnia and Herzegovina must become more productive and more economical in order for it to be competitive in the region.

In the process of intensive agricultural production, modern and high-precision mechanization is one of the preconditions for economical and quality food production. Considering the application of mechanization, it is not enough to have modern and high precision mechanization. Nowadays, the optimal setting and adaptation to the orchard geometry now plays a crucial role, both in the consumption of preparations, in the production of health-care foods, and in the protection of the environment.

Mechanized chemical protection of orchards is a complex and demanding measure (Bugarin et al., 2014). Therefore, it is of the utmost importance that this measure be carried out in a quality manner with properly prepared sprayers.

In order to achieve the maximum precise application of pesticides and complete protection of crops, it is not sufficient for eaters to have only modern construction, but it is also necessary to have adequate exploitation potential (Đukić, 2008).

In the process of protecting apple from diseases and pests, the most commonly used chemical method is a great challenge, because it needs to be done quickly and in a quality manner without any consequences for the plant, the environment and man. So, it can be said that chemical protection has to be performed on time, in a high quality manner and without loss of preparations.

All of the above tells how important it is to permanently monitor the correctness and adjustment of the machines used in the application of pesticides.

The application device has the task to evenly allocate the device both on the surface and depth (inside the crown). The above is not easy to achieve in practice, since pesticides are now biologically very active and very small doses are used.

In addition to all of the above, and perhaps the most important prerequisite for quality application is calibration, that is, measuring and adjusting operating parameters to the orchard geometry.

Since there are various growing systems, as well as forms of fruit species, it is therefore necessary to take into account the optimum adjustment of the capacity of the device in order to meet the preconditions that provide the application without significant loss of working fluid.

Material and Methods

Sprayer testing was carried out in 2018 in an orchard owned by the "Gilmark doo. company", Trebovljani location, Gradiška. The first plot on which the survey was conducted is close to the water reservoir and its surface is 5.6 ha, while the second table surface is 6.8 ha and its distance from the water reservoir is 2.000 m. The length of the rows is 250 m.

The basic equipment used in the test was the atomizer AGP 1000 EN. The tractor unit IMT 560 with engine power of 45.6 kW was used as a traction unit. It has a crimped shaft of 34.9 mm diameter, with adjustable speed setting-540 - 1,000 rpm. The pump used to fill the tank has a SUS engine, and its capacity is 300 l/min.

The research was carried out at the rate of 1,000 l/ha, at the beginning of April 2018. Nozzles are produced by Lechler, type TR 80-02 yellow code and red TR 80-04 code, with working angle of 80°. During the research, a working pressure of 10 bar was used, and the nominal capacity of the sprayer at the given pressure was 1.42 l/min, or 2.83 l/min. When selecting the treatment standard, two of the most important parameters must be synchronized: the operating speed and the capacity of the device. The operating speed should be 5 km/h, since this is a slightly sloping terrain, while the expected capacity of the device is 33.96 l/min. Based on the determined parameters the achieved norm should be 1.020 l/ha.

Exploitation tests of aggregates were determined by the chronometry method and mathematical data processing.

Sprayer capacity control involves a one-minute flow measurement and is compared to the nominal value. It is performed using a capacity control device. Good tuning of all operating parameters in combination with controlled sprinklers ensures equal quality of protection when applying small and medium treatment norms (Sedlar, 2015).

Sedlar et al. (2008, 2009) also worked on determining the geometry of the flow. They state that proper flow geometry in accordance with the tree geometry is very important in terms of reducing losses and achieving an environmentally friendly application of pesticides.

With the application of chemical thinning agents for apple production, proper geometry of the nozzle and directing it towards the upper part of the tree, with appropriate weather conditions, is the key to success, according to Sedlar (2010).

Pergher (2004) conducted experiments to determine the positive effect of calibration of a sprayer with a vertical spray scanner. A conventional axial blower and circular sprayer arrangement - "Fiulli-Inox 600" was used for testing.

Chronometric recording of the work of the aggregate consists of the measurement of the following operations: the time of filling the reservoir tank (t1), the time spent on the path from the scattering point to the table-plot (t2), the aggregate turning time at the end of the line (t3), the time of the aggregate (t4), the time spent on the route from the plot to the location of the tank (t5). Based on these parameters, the working speed of aggregates and the theoretical productivity of aggregates are determined.

Based on chronometry and other operating parameters, the method implies that the field coefficient of operating time is determined during field exploitation of the aggregate. The above will include two models that imply two treatment standards while maintaining the dose of the preparation. The method involves monitoring and measuring the existing time in the agro-technical operation - plant protection. During the test, the time taken on the basis of which the operating time coefficient (τ_{sm}) was obtained, directly influencing the production of the aggregates, was measured. The research should provide answers to important questions regarding the possibility of reducing the number of aggregates in protection, and compliance with the application deadlines.

Results and Discussion

The measurements results presented in Table 1 prior to control involve the exploitation of the aggregates before adjusting or adjusting to the planting geometry. The actual capacity of the device is 35.70 l/min, which, when selecting the mentioned parameters, provides a standard of 1.070 l/ha.

Model B represents a complete exclusion of the flow of certain sprinkler positions that produce losses in the form of a land drift, or the selection of a sprinkler in a position where a smaller capacity is required (Table 1).

An appropriate calibration model involves adjusting the device in terms of the capacity of the sprinkler to certain positions in the geometry of the treated plant.

Tab. 1. Sprayer capacity by position (before and after control)

Position	Sprayer capacity (<i>l/min</i>)			
	before control (A)		after control (B)	
	Left	Right	Left	Right
1.	3.40	2.90	1.40	1.40
2.	2.80	2.80	2.80	2.80
3.	3.10	2.90	3.10	2.90
4.	2.80	2.90	2.80	2.90
5.	2.90	2.80	2.90	2.80
6.	3.40	3.40	0.00	0.00
Total	18.00	17.70	13.00	12.80
	35.70		25.80	
Norm	1.070 (<i>l/ha</i>)		770 (<i>l/ha</i>)	

After the treatment model A, model B, which includes corrections in terms of the capacity of the sprayer, was made, with the aim to reduce losses. The actual capacity of the device in model B is 25.80 l/min, with a standard of 770 l/ha.

Model B represents a complete exclusion of the flow of certain sprinkler positions that produce losses in the form of a land drift, or the selection of a sprinkler in a position where a smaller capacity is required (Table 1).

The tested aggregate during its operation achieved an average operating speed of 5.10 km/h. The speed received is controlled by the speed formula, all based on the travelled time and the measured time with the stopwatch. The average time spent on the inundations is 11.6 sec.

Tab. 2. Time measurement results and achieved protection parameters

Model	Duration of the transport cycle (min)					v (km/h)	Wh (ha/h)
	t1	t2	t3	t4	t5		
50 m- distance of the parcel							
A ₁	5	2	4	35	2	5.10	1.25
B ₁	5	2	6	42	2	5.00	1.47
2.000 m- distance of the parcel							
A ₂	5	8	5	34	6	5.10	1.03
B ₂	5	8	6	42	6	5.20	1.25

The average time required to fill the reservoir and prepare the mixture is about 5 minutes in all tested models. Time related to departure and return to the parcel treated did not deviate significantly from all tested models. The time t_3 and t_4 of the aggregate in treatment with model B are slightly longer because the above model provides greater surface coverage due to the correction of the norm, and therefore the protection of a larger area. The measurement showed the time spent in the treatment of model A 35 and 34 minutes, while model B had slightly more time spent on treatment because of greater coverage, and it was 42 minutes in both cases.

Controlling the capacity of the sprinkler and increasing the precision of the device is the most important segment of the device's adaptation to the geometry of the plant, and everything has nevertheless a positive effect on increasing the productivity of the aggregate operation. This is reflected in an increase in effect of 0.22 ha/h for both distances covered by the survey. It can be concluded from the above that increasing the hours of exploitation of the aggregate during the shift increases labour productivity.

By analyzing the total energy inputs of orchard protection for different application models, a smaller energy input is noticeable when using controlled devices on a 50 m range by 7.58%. Energy inputs on a further distance plot are by 24.68% lower in favour of the treatment of the controlled sprayer. Lower consumption of fuel, water, human and machine work have decisive influence on the reduction of energy input in protection. In the case of filling the reservoir at greater distances, which is often the case in practice, the energy equivalent of fuel consumption costs greatly increases energy input. Thus, the total energy input implies the costs of transporting water that is directly dependent on the required amount of water for treatment, the number of aggregates, and therefore the number of aggregate operators, the number of working hours for performing the treatment in optimal agro-technical conditions.

Tab. 3. Productivity exploitation parameters

Model	Plot distance (m)	Surface treated with a single tank (ha)	Duration (min)	Number of cycle	Effect for ha/10h	τ_{sm}	Improve performance (ha)
A ₁	50	1.00	48	12.50	12.50	0.73	2.24
B ₁		1.40	57	10.53	14.74	0.74	
A ₂	2.000	1.00	58	10.34	10.34	0.59	2.20
B ₂		1.40	67	8.96	12.54	0.63	

The productivity of the aggregate model B is higher on the 50 m distance by 2.24 ha, while the productivity of the aggregate representing the results of model B at a distance of 2.000 m is higher by 2.20 ha for a ten-hour operating time than in model A. The higher productivity of the aggregate is achieved thanks to the greater surface coverage of the model, which implies the exploitation of a controlled thinner, that is, a model that provides greater accuracy of the application. In the realization of agro-technical measure protection, treatments are performed even after 16 hours a day without interruption, all for the purpose of timely treatment. The aforementioned has a positive effect on productivity, and the devices of model B have achieved even greater productivity by 3.52 ha in both cases.

Coefficients of operating hours are approximate values of the compared models, but they are somewhat smaller in the further plot, which is also expected due to the greater share of time spent in transport. The difference in the operating time coefficient is greater when the treatment is carried out on a 2,000 m distance plot.

Conclusion

Treatment with a controlled device has multiple advantages over the uncontrolled one, and it is reflected in better quality uniformity from the aspect of vertical distribution, more uniform and better coverage of plant parts, pesticides saving, increased effect of human and machine work, increase in productivity and lower cost of protection.

Higher productivity of the aggregate was achieved with the exploitation of the controlled device, and it is reflected in the greater coverage of the target surface, that is, the model that provides greater accuracy of the application.

By analysing the total exploitation parameters of orchard protection, different application models point to a smaller energy input when using controlled devices on a 50 m range by 7.58%. Exploitation parameters on a further distance plot are by 24.68% lower in favour of the treatment with the controlled sprayer.

The research presented in this paper once again confirmed the need to change the approach to pesticide application, that is, the need to pay more attention to setting work parameters in line with planting needs and specificities.

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Утицај контроле орошивача на повећање производности машинско-тракторског агрегата при заштити воћњака

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Сажетак

Правилно формирање тракторско-машинског агрегата треба да удовољи захтјевима агротехнике са аспекта квалитета рада, да обезбједи рационално коришћење машина, односно високу производност и мање трошкове рада. При заштити вишегодишњег засада извршено је истраживање на површини 150 *ha*, а примјењује се метода орошавања или распршивања. При овој методи користе се машине под називом орошивачи, код којих се, уз присуство произведене ваздушне струје, врши и дезинтеграција течности на величину капи од 50 до 150 μm . Циљ истраживања јесте у оквиру контроле уређаја побољшати прецизност рада гдје се првенствено ставља акценат на капацитет дизни, а самим тим и повећање производности уређаја. У раду су приказани резултати испитивања вученог орошивача, запремине резервоара 1.000 *l*. Остварени резултати на бази десеточасовног радног времена доказују да експлоатација контролисаног орошивача обезбјеђује већу производност уређаја за 2,24 *ha* на парцели удаљеној 50 *m* од мјеста точења резервоара, односно 2,20 *ha* на удаљености од 2000 *m*. Анализом укупних енергетских инпута заштите воћњака различитим моделима апликације уочавају се мањи енергетски инпути при примјени контролисаних уређаја на парцели удаљености 50 *m* за 7,58 %. Енергетски инпути на парцели веће удаљености су за 24,68 % мањи у корист третмана контролисаним орошивачем.

Кључне ријечи: засад јабуке, апликација, орошивач, производност

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