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Zoran MALIČEVIĆ[1],
Željko LAKIĆ[2],Milena ĐOKIĆ*[3]

INFLUENCE OF NOZZLE CONTROL ON INCREASING THE WORK QUALITY AND REDUCING LOSSES

SUMMARY

When developing agricultural sprayers, it is desirable to follow measures and procedures that would result in minimal impacts on the ecosystem. With the technical perfection of the machine for plant protection, it is especially important to adjust the technical parameters of application of pesticides - working speed, working pressure, air flow and speed, spraying norm, type of sprayer, etc.

The aim of the research is to define the jet geometry in accordance with the average canopy geometry, with the task of increasing the efficiency of the application by adjusting the parameters to the treatment conditions. The result is a reduction in the risk of environmental impact, through a reduction in losses.

The norm of 530 l/ha, achieved a slightly higher coverage on the target area of 56.27% on the left side, while the right side is slightly less covered with 46.08% coverage. The highest norm in the research was 650 l/ha with an average coverage of 56.28%, ie a coverage of 64.48% on the left side and 48.09% on the right side of the unit.

Keywords: control, efficiency, nozzle, losses

INTRODUCTION

The application of pesticides in fruit-growing is of paramount importance, since the product from perennial plantations is consumed directly by the users without any processed processing (Sedlar, 2018).

Plant protection today is not easy to perform since protective agents are now more biologically active and very small doses of up to several grams or mililitar per hectare (g,ml/ha). Precise application of pesticides has multiple advantages: environmental effect, protection efficiency as well as reduction of

[1]Zoran Maličević, Faculty of Agriculture, University of Banja Luka, Republic of Srpska, BOSNIA AND HERZEGOVINA;
[2]Željko Lakić, Institute for Agriculture Banja Luka, Republic of Srpska, BOSNIA AND HERZEGOVINA;
[3]Milena Đokić (correspondence author: milena.dj1405@gmail.com), University of Montenegro, Biotechnical Faculty Podgorica, MONTENEGRO.
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input input in production. With the technical correctness of the plant protection plant, it is especially important to adjust the technical parameters of spraying – operating sprinkler speed, operating pressure, airflow and speed, spraying norm, type of sprayer, etc (Bugarin, 2017). For the proper and successful use of pesticides it is especially important to select the appropriate sprayers. Also, working with appropriate pressure has a major impact on the effectiveness of treatment (Sedlar, 2017). One of the basic requirements in mechanized fruit protection is that the jet of liquid and air current is directed and deposited on the crown of the plant, all with the aim of reducing losses and increasing the effect of protection. All of the above can only be achieved by properly adjusting the spray parameters such as: operating speed of the device, operating pressure, amount of air, amount of liquid per unit area and type of sprayer. Only optimally selected application parameters and technical correctness and reliability of the device give adequate results.

Improperly selected application parameters affect poor coverage of the canopy, environmental contamination through increased loss of preparation, increased consumption of protective agent, increased water consumption per unit area, poor penetration of protective agent into the canopy and other negative influences that lead to pest recurrence.

Considering that the price of pesticides is growing from year to year, the protection devices are expected to enable the highest efficiency of chemical preparations, optimal economy, and the least possible endangerment of the environment and the lowest possible toxicity for the operator of the unit.

Exploitation of nozzles with a nozzle ring around the axial fan in such conditions becomes critical from the aspect of imprecise application, ie nervous distribution of the preparation along the height of the canopy, and in addition there are large losses in the form of drift.

Quality control of the nozzle greatly eliminates the above, and positively affects the accuracy of work and distribution efficiency of the nozzle. The decrease in the quality of the spraying application is due to disturbances of technical parameters, malfunctions and insufficient knowledge of the device by the operator.

Sprayers as the final elements of the sprayer determine the size of the droplets, the shape and angle of the outlet jet, the amount of liquid and the quality of covering the treated surface (Đukić, 2001).

The condition of the nozzle, ie the type and position of the nozzle on the nozzle with the appropriate flow, greatly affects the efficiency of the entire device, and the condition from the aspect of expansion or clogging can cause large deviations and protection problems (Maličević, 2016).

The conducted controls on the territory of Republika Srpska and Bosnia and Herzegovina also indicate the fact that the malfunction and poor exploitation potential are mostly affected by nozzles and faulty manometers (Maličević, 2012). In the production conditions of BiH, a significant problem is the habit of agricultural producers to buy parts of dubious quality whose only advantage is the low price. A special risk is the choice of nozzles of questionable quality. Especially in such a situation, the positive effect of correctness control comes to the fore, and the aim of this paper is to point out the importance of quality control of nozzles, which are the most common cause of deviations in application. The use of water-sensitive papers (WSP) is a fast and reliable method for assessing the quality of the application, which is the ultimate goal of the research.

MATERIAL AND METHODS

The agricultural farm of the Čekić family, where the research was conducted, is located at the sloaps of the Kozara mountain, in the village of Grbavci near Gradiška. The experiment was performed in the second half of March 2019, T=18 degrees, east wind at intervals of 1.60 to 4.20 m/s, relative humidity 58%. The sprayer used in the research is Zupan-ZM 600 S, with a tank volume of 600 l.

Nozzle testing included checking the condition and speed of the tractor's PTO shaft, visual inspection of tanks, flexible hoses, filters and valves, measuring pump capacity, nozzle capacity control, as well as determining the uniformity of pesticide distribution on the left and right side of the device and manometer correctness. The following instruments were used for testing: pump capacity meter, nozzle capacity meter, manotaster, stopwatch and non-contact PVT tractor speed meter. The PTO shaft speed and PTO shaft condition were checked.

With the speedometer, the speed of the PTO shaft was checked and it was determined that it provides 540 rpm, which is the nominal speed. The pump capacity is measured using a flow meter, and is expressed in l/min and compared to the rated capacity.

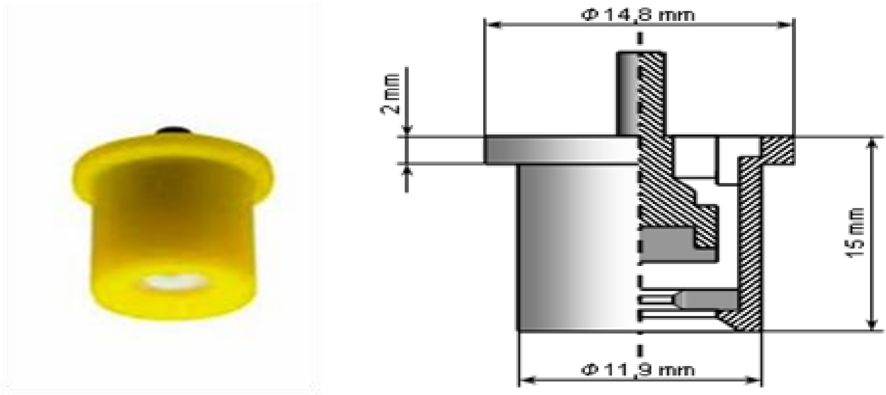
Manotest involves checking the condition of the manometer. A.A.M.S manotaster was used to control the correct operation of the manometer. The measurement of the correctness of the manometer was performed with a control manometer calibrated according to the standard EN 837-1. Nozzles are the final elements and the distribution and even distribution of pesticides on the treated surface largely depends on them (Sedlar, 2008).

The laboratory has a mechanical flow meter consisting of 12 transparent beakers (volume 2,000 ml) which are connected using an adapter on the nozzles according to the system, each beaker is connected to one nozzle. After connection, the sprayer is put into operation at a certain pressure for 1 minute at the most commonly used working pressure, followed by reading and comparison.

The nozzles used (Figure 1) achieve an operating angle of 80° and specific fluid flows at a certain operating pressure. Therefore, nozzles according to the ISO10625 standard achieve the following liquid flows, ie. nominal capacities:

-AlbuzATR 80 – 212, yellow codings: 0,3 AG/min or 0,58l/min;

-AlbuzATR 80 – 220, red codings: 0,2 AG/min or 0,88l/min.



a) b)

Figure 1. Technical characteristics of the nozzle Albuz ATR 212, www.albuz.com

The achieved treatment norm is conditioned by two basic parameters (speed of aggregate movement and total capacity of the device). The achieved speed of movement is determined by the conditions and condition of the terrain where the treatment is performed, and ranges from 5 to 8 km/h, and even more where the conditions of application allow (extremely flat terrain).

$$N = \frac{Q_p \times 600}{B_r \times v_r} \quad (l/ha) \tag{1}$$

Where is:

N - Treatment norm (l/ha),
Qp - Device capacity (l/min),
600 - Correction factor,
Br - Inter-row spacing in the orchard (m) and
vr - Unit operating speed (km/h).

The basic parameters for achieving controlled application of pesticides are the speed of movement and the capacity of the device. Speed check was performed using the form:

$$v = \frac{s}{t} \quad (km/h)$$

Where is:

v- speed (km/h),
s - distance traveled (m),
t - time (s).

The quality of the treatment was determined using special water-sensitive papers (WSP) with a yellow base. During treatment, droplets fall on the WSP and leave dark blue marks. At all marked measuring points, WSP of the same dimensions are placed on the tile supports that are placed in a row and on the ground.

With the advancement of technology, the use of the WSP scanning method and software processing of the obtained image began (Wolf 1999, 2003, 2004; Sumneret *et al*. 2000; Mahmood *et al*. 2004). The WSPs are placed at 7 positions in the intermediate row through which the aggregate passes, and at three positions in the adjacent intermediate row on the left and right, a total of thirteen measuring points for monitoring losses on the ground.

Tiles that measure the quality of protection on the supports in a row are placed in four positions on the left side of the device and four on the right side at a distance of every 0.6 m from the ground surface.

After passing the aggregate, the WSPs are removed and marked in zones. WSPs processing is performed in laboratory conditions.

After collection and labeling, the WSPs are further sent for scanning and processing using *ImageJ 1.44* to determine the intensity of coverage.

RESULTS AND DISCUSSION

The quality of the application, and thus the reduced efficiency of protection, is affected by the increased loss of working fluid that occurs due to poor setup of the device. The control of the sprinkler operation is reflected in the fact that it is a technical system whose functionality has been uncertain after a certain period of operation.

The presented results of pump capacity measurements were achieved at operating pressures of 5, 10 and 15 bar. (Table 1).

Table 1. Pump capacity at different pressure

Pressusre (*Bar*)	Pump capacity (*l/min*)
5,00	104
10,00	98
15,00	91

The values in the table 1 show a decrease in pump capacity when pressure increased. In the case of a longer period of sprayer operation, the capacity values at higher pressures may be lower than the nominal one. In that case, it is necessary to repair the pump in terms of changing the working parts (pump membrane, valves and pistons).

Numerous studies confirm that by increasing the working pressure, better transverse distribution and better surface coverage are obtained. Sedlar (2017) shows that by applying higher rates, the product is deposited locally, while other parts of the plant remain without deposits, so there are greater losses. An environmentally friendly technique for pesticide application has been developed with the aim of reducing pesticide consumption, while increasing their efficiency and reducing drift losses (Sedlar, 2009).

The sprayer used in the test is equipped with Albuz ATR 212-yellow code nozzles, with a nominal capacity of 1.06 l/min at a pressure of 10 bar. The tested sprinkler has seven nozzles on the left and seven on the right side. Nozzles were tested using measuring beakers, ie. at a certain pressure they were put into operation for one minute (they were tested at a pressure of 10 bar).

Table 2. Results of nozzle capacity measurement on the left and right side of the sprayer

Nozzle position	Nozzle capacity (*l/min*)			
	Left side of the sprayer	Right side of the sprayer	Left side of the sprayer	Right side of the sprayer
	Before calibration		After calibration	
	ATR 212	ATR 212	ATR 212	ATR 212
1.	1,20	1,50	1,20	1,10
2.	1,60	1,10	1,30	1,50
3.	1,30	1,30	1,60	1,30
4.	1,10	1,40	1,10	1,40
5.	1,10	1,70	1,10	1,70
6.	1,10	1,20	1,10	1,40
7.	1,10	1,40	1,00	1,20
Total	8,40	9,60	8,40	9,60

Table 2 shows the deviation of the device capacity towards the sides, which significantly affects the efficiency of treatment in terms of uniform distribution of the pesticide to the target surface.

When it comes to standards, the following can be said: the capacity of the device during the operation of the Albuz ATR 212 sprayer was 18.00 l/min. Taking into account other parameters for calculation, such as: row spacing 3.2 m, aggregate speed 5.18 km/h, 6.40 km/h and 9.20 km/h, and by inserting in the form (1) the norms were: 530 l/ha, 650 l/ha, or 370 l/ha.

The calibration procedure involved replacing the nozzles at positions two and three on the left side of the device, and positions one and two, and six and seven on the right side of the device, respectively. The calibration had the task of adjusting the capacities of individual positions of the nozzles to the geometry of the plantations, all with the aim of increasing the efficiency of the device.

The flow results before adjustment and calibration are shown in the histogram of Figure 2, while Figure 3 shows the arrangement of the nozzles to meet the optimal calibration according to the application conditions - geometry of plantations.

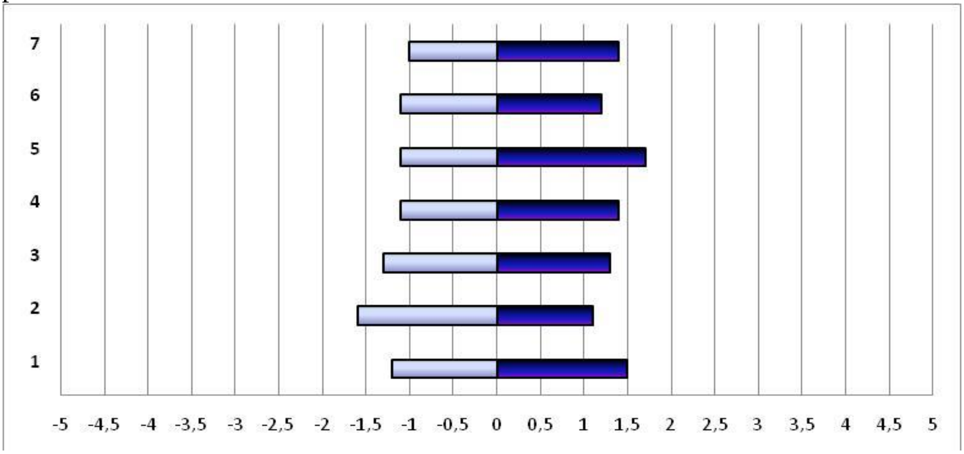


Figure 2. Histogram of sprayer distribution, before calibration

Figure 2 shows the capacity of the sprinkler adjusted to the shape of the canopy, ie. adjustments were made as a function of the required amount for a particular canopy zone. Modern sprayer enable quick adaptation of devices to different standards from the aspect of sprayer use (min. 2 types of nozzles per position, and some even more), all with the aim of enabling different treatment standards and device calibration.

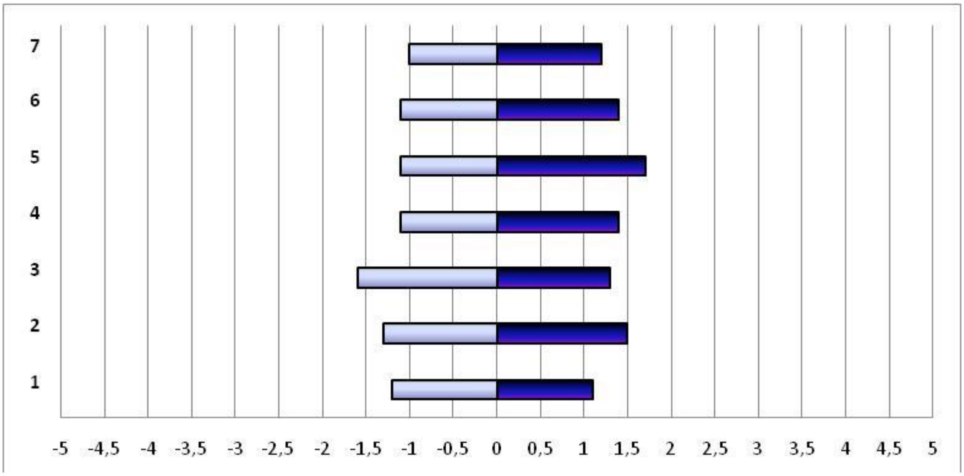


Figure 3. Histogram of sprayer distribution, after calibration

The sprayer used is equipped with two types of nozzles (ATR 212, yellow coding and ATR 220, red coding). In practice, this should be used to make the calibration process easy. The different type of nozzle enables fast and efficient selection of nozzle of appropriate capacity according to positions.

The importance of proper calibration is numerous: it enables controlled application (the manufacturer knows exactly how much fluid consumption spent according to the surface of the plantation), optimal fluid consumption according to certain canopy zones, appropriate nozzle capacity according to positions, can reduce working fluid losses, etc.

Table 3. Achieved results of WSP coverage in the crown zone

Treatment rate (*l/ha*)	WSP coverage [%]								
	Left line				Right line				
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	
370	57,50	59,14	55,92	65,27	22,36	29,86	36,46	15,67	42,77
	58,63				26,08				
530	68,32	67,14	41,53	48,12	37,54	69,87	38,06	38,88	51,17
	56,27				46,08				
650	67,23	57,34	63,86	69,52	34,87	69,81	48,45	39,25	56,28
	64,48				48,09				

Where is:

1-WSP position at height 0,60 m
2-WSP position at height 1,20 m
3-WSP position at height 1,80 m
4-WSP position at height 2,40 m

The achieved results are shown in Table 3, and show the coverage for the three norms achieved in the research. The lowest coverage, which was to be expected, was achieved by the norm of 370 l/ha, and the achieved average coverage of water-sensitive papers is 42.77%. The coverage achieved during the treatment can be considered satisfactory, since it was achieved in one pass of the aggregate. What the achieved results show and can be a problem in the protection is the inequality of the left and right side, which amounts to 58.63% and 26.08%, respectively. The achieved results, more or less in all treatments, are reflected in the lower coverage on the right side, which is the result of the wind on the right side of the unit that blew at intervals of 1.60-4.20 m/s. The achieved coverage results imply one pass of the aggregate, which means that the next pass, ie. through the right and left intermediate rows significantly equalized the coverage of both rows.

The treatment, which includes the norm of 530 l/ha, achieved a slightly higher coverage of the target area and it amounts to 56.27% of the left side, while the right side is also slightly less covered for the reasons already mentioned and amounts to 46.08%. With this treatment, there is a slightly smaller difference in the coverage of the sides, which can be associated with a larger amount of liquid, ie the intensity of the wind in gusts, on the right side of the device.

The highest applied norm in the research was 650 l/ha with an average coverage of 56.28%, i.e. coverage of 64.48% on the left side and 48.09% on the right side of the unit was achieved.

CONCLUSIONS

The conducted research and analysis indicate the need for regular control of the capacity of the nozzles, because the quality of the application and the reduction of losses largely depend on their condition.

Not enough attention is given to the control of vertical distribution, however, these studies have shown that it is perhaps the most important segment in the quality and precise application of pesticides. At the norm of 530 l/ha, the coverage was 56.27% on the left and 46.08% on the right. The norm of 650 l/ha achieved an average coverage of 56.28%, ie. coverage of 64.48% on the left side and 48.09% on the right side of the unit was achieved. The results presented in this paper once again confirmed the need to change the approach to pesticide application, ie the need to pay more attention to adjusting all operating parameters, especially the position of the nozzle in accordance with the needs and specifics of orchards and weather conditions. When testing the capacity of the sprayer, it is often the case that, if the deviations beyond the limit are not allowed by the standard, by rotating the position of the nozzle, we get a more efficient and precise device. In this case, that opportunity was used. This is exactly the purpose of controlling the capacity of the nozzle, and adjusting the device to the geometry of the plant.

This measure provides a much better application without additional investment in terms of purchasing new nozzles.

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