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EFFECT OF PRESSURE ON THE UNIFORMITY OF NOZZLES TRANSVERSE DISTRIBUTION AND MATHEMATICAL MODEL DEVELOPMENT

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Abstract

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Timely and high-quality application of pesticides contributes to environmental protection, economical production and production of healthy food. The efficacy of pesticide application depends not only on the quality of pesticides but also the quality of the application. One of the factor that most influences the quality of applications, from the standpoint of mechanization, are nozzles. They working liquid applied on the surface the plant resulting in the same volume of pesticide is applied to the entire surface of the plants. To achieve this goal, nozzles must be performed uniform application of working liquid per unit area, or tractor sprayer working width. The variable factor in the application of pesticides may be nozzle and operating pressure. With increasing working pressure obtained smaller droplets. The paper presents test of three different nozzles. Each nozzle is characterized by a flat jet with an angle of 110° and a flow rate of 1.6 l·min^{-1} at a pressure of 3 bar. Differ from each other are by the way of disintegration of the jet. Exactly this characteristic causes that with pressure change coming to changes in the uniformity of nozzles transverse distribution. So the best distribution has nozzle with a flat jet. The coefficient of variation is between roughly from 4 to 6 % at the pressure application of 2 to 4 bar. Obtained mathematical model that describes changes in the coefficient of variation depending on pressure applications can be a good basis for easy harmonization parameters in the pesticide application.

Keywords: nozzle, coefficient of variation, uniformity of distribution, operating pressure, sprayer, flow, disintegration.

INTRODUCTION

One effort in the sustainability of agricultural production is reflected in preservation and protection of land for future generations. Sustainability is partly reflected in the effective and economical application of plant protection products. Timely and high-quality application of pesticides contributes to environmental protection, economic production and the production of healthy food. Pesticide manufacturers outline the amount of pesticides in combating causes of diseases and weeds in crops or in any part does not deal with the details of the application of pesticides. The efficiency of the application depends not only on the quality of pesticides but also the quality of the applications. The application of pesticides is not only limited to the environmental conditions in which the application is made, but also the exploitation factors. Each machine protection products, in this case the field sprayer must be in perfect condition when applying pesticides in accordance with applicable standards. The operator or directly through farmer responsible for the quality and efficiency of applications. Faced with this problem the farmer has to recognize the critical factors and master them. Many years of experience can help or faced with frequent changes and different vegetation conditions, it is not enough.

The accuracy of mounted sprayer to protect field crops is mainly confined to the accuracy of pumps and nozzles. These are critical points of the sprayer and the main factors of successful applications (Smith *et al.*, 2000). Servicing the pump is relatively fast and easily leads to a good condition. For nozzles, situation is similar as in plant protection products. When there is a need to carry out a treatment to prevent or crops due to diseases and weeds, information about it can be obtained from plant protection advisor to companies that sell their products. This includes information about the preparation to be used, standards, application techniques, re-treatment, etc. In contrast to the method of application and use of plant protection products, information on the application of specific nozzles to increase the efficiency of the applied pesticide is not easy to get. Always obtain information that is the best preparation is used or not and to which nozzle can increase efficiency.

The factor that most influences the quality of applications from the standpoint of machinery for pesticide application, are nozzles. Those working liquid applied to the surface of the plant resulting in that an amount of the pesticide found on the surface of the plant. To be quite certain amount of pesticide standards, found on the surface of plants, nozzles must be made uniform application of working liquid per unit area (Wang *et al.*, 1995). Uniformity pesticide application is the same as uniformity of a distribution is estimated using the coefficient of variation (Balsari *et al.*, 1994). The coefficient of variation (Cv) is the relationship (ratio) between the standard deviation and the mean. Is expressed as a percentage. What is the coefficient of variation is lower; it is more uniformity of application (Javier *et al.*, 2008; Jean *et al.*, 2012).

Information on the coefficient of variation points directly on the quality of applications. When the coefficient of variation of less than 7 % of the then outstanding uniformity of distribution. If this value is greater than 7 % to 9 %, the uniformity is satisfactory. The coefficient of variation is tolerated up to 11 % or over this limit uniformity of distribution is declared as insufficient (Drocas, 2009).

On the coefficient of variation affecting the working pressure pumping applications and the way of disintegration of the working fluid through the nozzles (Al Gadi, 1998, 2010; Drocas, 2009). Every farmer knows in advance that will speed switch, which will carry out a working pressure application and which possesses the sprayer nozzles to the flow. Based on this information a farmer can predict only some output parameter applications or one of the most important parameters in the application and that the coefficient of variation does not know. This information does not exist because the farmer is nowhere indicated the coefficient of variation for a given input parameter applications and anywhere you can get and what is very important for the effect of treatment (Womac *et al.*, 1999, 2001).

The quality of applications was investigated by many authors, and in every work of their research base on the coefficient of variation. Already Đukić and Sedlar (2002) state benefits and working principle of injector nozzles as well as newer and better solutions pesticide application. The same authors after the tests mentioned nozzles conclude that the injection nozzles are extremely good in pesticide in real terms (Sedlar *et al.*, 2013; Bulgarian, 2013; Sedlar *et al.*, 2009; Sedlar *et al.*, 2009b; Đukić and Sedlar, 2002).

Task work is that the three types nozzles with flat jet tested in laboratory conditions. The test will be carried out according to the operating parameters recommended by the manufacturer. The data is the coefficient of variation then enter the program Mathematics 9 Tungsten (Wolfram Mathematica 9). The aim of this research was to investigate the effect of pressure on the uniformity of transverse distribution and to define mathematical models of these changes.

MATERIALS AND METHODS

In the laboratory control techniques for pesticide application, the Department of Agricultural Engineering, Faculty of Agriculture, University of Novi Sad measured the transverse distribution of three different nozzles. The transverse distribution nozzles or boom is measured by horizontal paternatora, known as spray scanner. The spray scanner has 8 channels, grooves that collect liquid distributed by nozzles and implemented in cylinders. In a graduated cylinder is electronically measured amount of water in one channel and calculates the value that is displayed on the graph. Each has two measuring point, contacts. One contact is in the bottom of the tube and the other is at the top. Through lower contact is leaking electricity, which registers the upper contact or only after measuring cylinder filled with water, liquid. For a completely uniform distribution of all the cylinders are filled at the same time, and the transverse distribution entirely uniform. However, when the tubes are not charged at the same time the distribution is not entirely uniform or nozzles not distribute the same amount of fluids throughout the treated area. To register contact and based on this diagram is to say the transverse distribution. The diagram shows the values that are more or less deviate from the mean transverse distribution.

The laboratory used to spray scanner width 1200 × 800 mm. Scanner width is 800 mm and the boom is measured from multiple times, depending on the working width of the sprayer. Spray scanner moves on rails and on every 800 mm of the sensor where the scanner is stopped and conduct testing, measurement (Fig. 1).

1: *Spray scanner*

The mean transverse distribution of the mean value of the bulk liquid distributed by the treated surface. Percentage deviation from this mean value represents the coefficient of variation. The coefficient of variation allows the comparison of different nozzles in various modes (Višacki *et al.*, 2013).

On both wings of the total structural interventions 6 m in the triple rack nozzles were installed three different nozzles company Geoline and with markings AZ 110-04, 110-04 and ST60 STIA 110-04. The said instrument recorded the flow at every 0.8 m working width boom, a total of 6 m working width. Humidity exceeded 63 %, while the temperature was around 18 °C.

Spray scanner recorded a total flow nozzles and coefficient of variation. Graph and recorded values were shown and stored in the computer memory by supporting a program designed to work with spray scanner. Calibration of the scanner is performed before each series of measurements for each nozzle a total of 3 times.

The measurement was performed in 3 repetitions at different pressure applications. Test bench for agricultural spraying is set to piston-diaphragm pump with two working chambers powered wings working fluid (in this case it was tap water) without stopping at speeds of 540/min^{-1}. The aforementioned nozzles get fluid working pressure of 2 bar, 2.5 bar, 3 bar, 3.5 bar and 4 bar and respectively 2 bar, 3 bar, 4 bar, 5 bar and 6 bar for nozzle STIA. Booms height of the spray scanner was 0.5 m. Booms and rails on which the moving instrument for measuring the transverse distribution were parallel.

With the help of these input parameters, the type of nozzles and working pressure will get the coefficient of variation for each combination of independent variables. When the gain coefficient of variation then we can generate a variation coefficient curve changes depending on the pressure.

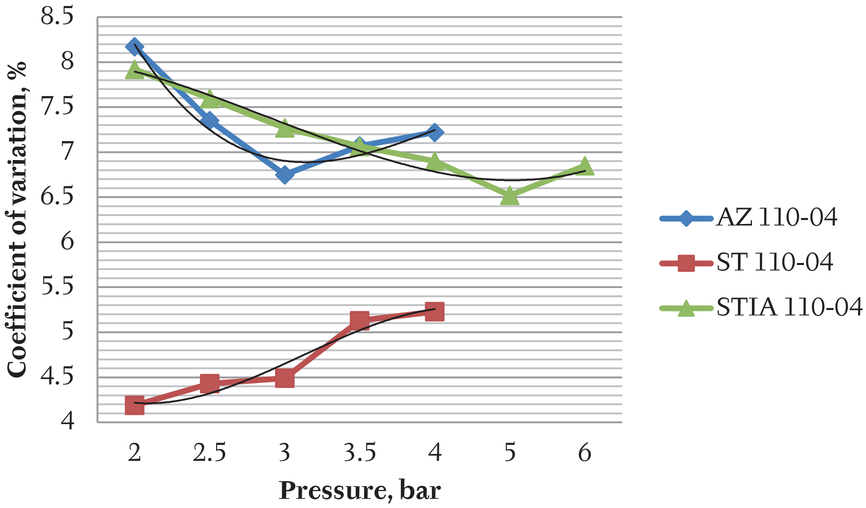
RESULTS AND DISCUSSION

The Tab. I shows the results obtained coefficients of variation transverse distribution.

According to the manufacturer, nozzle ST 110-04 was tested at higher pressures. This is the injector nozzle with a flat jet T shape and jet angle of 110°. Characteristically for this is that nozzle exerts its characteristics and purpose justifies at higher pressure applications. In this respect, still expectations injector nozzles that make smaller grouped drops at higher pressures, and to be distributed evenly by the treated surface. The main characteristics of this type nozzles are manifested at pressures greater than 4 bar, where the coefficient of variation decreases below 7 %. Thus, had the lowest coefficient of variation in STIA nozzles at a pressure of 5 bar in the amount of 6.52 %. A similar transverse distribution are at a pressure of 4 bar to 6 bar respectively, where the coefficient of variation of 6.9 % respectively 6.85 %. For lower operating pressures, the coefficient of variation ranges up to 8 %, respectively 7.92 at a pressure of 2 bar. These values are expected because we have more droplets grouped into one large, which because of weight its falls right after exiting the nozzles. On the other hand, the conventional nozzle with a flat jet T has a coefficient of variation of 8.17 % at the lowest recommended operating pressure of 2 bar. With increasing pressure applications, the variation coefficient decreases to 6.75 % at a pressure of 3 bar and then with further increasing the pressure increases. More specifically, when the increase to the maximum recommended pressure 4 bar,

I: *Coefficients of variation for tested nozzles*

Pressure (bar)	Nozzles		
	AZ 110-04	**ST 110-04**	**STIA 110-04**
2	8.17	4.19	7.92
2,5	7.35	4.43	7.60
3	6.75	4.49	7.27
3,5	7.07	5.13	7.07
4	7.22	5.23	6.9
5	/	/	6.52
6	/	/	6.85



2: *Graph qualitative changes of pesticide application, depending on the pressure*

the quality of distribution, and it is declining 7.22 %. What is characteristic for this manufacturer, generated by the nozzle jet having an angle of 135° whose jet to 30° slanted relative to the vertical. Thus, when performing pesticide application, simply speaking, the first pass-wing sprayers, mounted sprayer respectively and then applied to the working fluid nozzle. Very important in the nozzles in that it has a uniformly pesticide application. The coefficient of variation as an indicator of quality transverse distribution at the nozzles range from 4.19 % at a pressure of 2 bar to 5.23 % at a pressure of 4 bar. With increasing pressure deteriorates the transverse distribution of liquid. The movement of the coefficient of variation is shown in the Fig. 2.

The data are entered into the program Wolfram Mathematica 9. For couples entered the pressure-CV were generated mathematical models of changes in the coefficient of variation depending on the change in pressure. Functions of the changes are as follows:

AZ 110-04:

$$y = -0{,}032x3 + 0{,}496x2 - 2{,}210x + 9{,}942;\ R^2 = 0{,}959$$

ST 110-04:

$$y = 0{,}010x3 - 0{,}088x2 - 0{,}070x + 8{,}043,\ R^2 = 0{,}961$$

STIA 110-04:

$$y = -0{,}03x3 + 0{,}291x2 - 0{,}558x + 4{,}514;\ R^2 = 0{,}940$$

For entered pressure values, x, we get the coefficient of variation given nozzles. By using these nozzles on tractor sprayers, famrer has the ability to obtain a parameter applications provided quality transverse distribution nozzles. This prevents the possibility of bad, uneconomical, inefficient application of pesticides. For further development of adequate and automatically kontorlisane application of pesticides such models will have a major role.

CONCLUSION

On the coefficient of variation affecting operating pressure and the way of disintegration working fluid through the nozzles. Every farmer knows in advance that will speed switch, which will carry out a working pressure application and which possesses the sprayer nozzles to the flow. In laboratory conditions were obtained coefficients of variation for sprinklers type AZ, ST and STIA. Changing the coefficient of variation is caused by the change in the operating pressure. Software that monitors the work and receive data from the horizontal paternatora calculate the coefficients of variation for the tested applications from a height of 0.5 m with a step change of 0.1 m as well as the test pressure of 2 bar to 4 bar in steps of 0.5 bar or from the 2 bar to 6 bar. Based on this, we defined the mathematical models. According to the obtained data, it can be concluded that:

- best transverse distribution of the atomizer nozzles has a flat jet, which jet for 30 ° angled at all tested pressures;
- coefficient of variation in the said nozzles ranges below 5 % at lower pressure applications which is very windy conditions humidity applications because they are larger drops;
- cV is a conventional flat spray nozzles ranges from 6.75 % to 8.17 %;
- a very good uniformity of distribution achieves injector nozzle with a jet;
- their essential characteristics of this nozzle is expressed at higher pressures than 4 bar.

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