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The Dependence of the Liquid Application on the Coverage of the Sprayed Objects in Terms of the Characteristics of the Sprayed Object during Spraying

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***Abstract*—**When assessing the quality of the spraying procedure, three indicators are used: uneven distribution of precipitation of liquid sprayed, degree of coverage of sprayed surfaces, and deposition of liquid spraying However, there is a lack of information on the relationship between the quality parameters of the procedure. Therefore, the research was carried out at the Institute of Agricultural Engineering of Wrocław University of Environmental and Life Sciences. The aim of the study was to determine the relationship between the degree of coverage of sprayed surfaces and the deposition of liquid in the aspect of the parametric characteristics of the protected plant using selected single and double stream nozzles. Experiments were conducted under laboratory conditions. The carrier of nozzles acted as an independent self-propelled sprayer used for spraying, whereas the parametric characteristics of plants were determined using artificial plants as the ratio of the vertical projection surface and the horizontal projection surface. The results and their analysis showed a strong and very strong correlation between the analyzed parameters in terms of the characteristics of the sprayed object.

***Keywords*—**Degree of coverage, deposition of liquid, nozzle, spraying.

I. INTRODUCTION

CHEMICAL plant protection is one of the most important procedures in modern agriculture, as a condition to obtain yields of high quality and in large quantity. The use of plant protection products can pose risks to humans, animals, and the environment [1]-[3]. Therefore, plant protection products should be used where it is indispensable and in the least quantity but at the same time to ensure the highest quality and effectiveness of the treatment [4], [5]. In assessing the quality of the spraying procedure, the used indicators are: uneven distribution of precipitation of liquid sprayed, degree of coverage of sprayed surfaces, and deposition of liquid spraying.

The degree of coverage when assessing the quality of a treatment is a quality parameter, whereas the application of a liquid should be considered as a quantitative indicator giving much more representative information on the quality and possible effectiveness of the treatment [6], [7]. Determining the degree of coverage is a much less complicated and much simpler study than determining the size of the application. Determining the relationship between coverage and application can allow forecasting and even estimation of the coverage ratio. Consequently, it will not only be possible to assess the quality, but also the effectiveness of spraying. Therefore, the purpose of the work was to determine the dependence of application liquid from the degree of coverage of sprayed objects in the aspect of the characteristics of a particular object.

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II. MATERIALS AND METHOD

The test stand consisted of carrier nozzles, which functioned as self-propelled sprayer, a control and driving system for carrier nozzles, and artificial plants.

A liquid spray was used in measuring the water with fluorescent label Brilliant Flavine Sulfo - BSF. The view of the test stand is shown in Fig. 1. The carrier nozzles moved along a 30-meter track along a straight line. In the first run - the runway - the carrier nozzles had a given speed, while the second (with a length of 15 m) was measured at the end where the carrier nozzles slowed down until it stopped completely.

There are six plants imitating plants (so-called artificial plants) on the path of the carrier in the measurement section. Up to three artificial plants were fitted with Syngenta's Water Sensitive Paper (WSP) and up to three filter papers to provide specific spray surface coefficients. The artificial plants were arranged alternately and they represented three replications of the measurements (Fig. 2). Samples are placed in such a way as to obtain specific horizontal surfaces - top and bottom and vertical - approach and leaving, right and left.

Parametric characteristics of the plant were determined on the basis of the spray surface coefficient proposed by the authors, taking into account the ratio of the surfaces sprayed in the vertical and horizontal projections.

$$W_{po} = \frac{vertical\ projection\ surfaces}{horizontal\ projection\ surfaces}\ [-]$$

For the studies, there were selected several coefficients: 0.25, 0.50, 0.75, 1, 1.25, 1.50, 1.75, 2, which were obtained when configuring surfaces of a certain orientation (Table I).

In each of the cases they assumed a constant sum of the areas of vertical and horizontal projections of 100 cm^2. The number of horizontal and vertical projection surfaces for the different spray surface coefficients is shown in Table II.

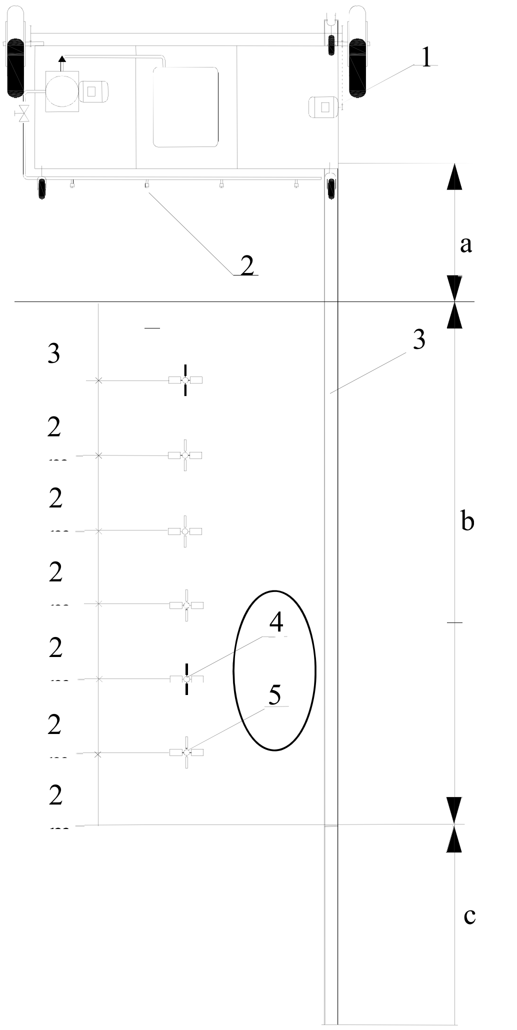
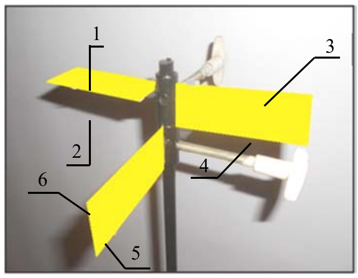


Fig. 1 Schematic representation of the measurement stand: a – run line, b – a measurement line, c – ending line, 1 – sprayers carrier, 2 – nozzles, 3 – fence, 4 – an artificial plant with WSP, 5 – an artificial plant with filter papers

TABLE I
CONFIGURATION OF PROBES ON ARTIFICIAL PLANT SPECIFIC AREA RATIOS OF SPRAY

Ratio of surfaces sprayed W_{po}	samplers on horizontal surfaces		samplers on vertical surfaces			
			transverse		longitudinal	
	top	bottom	approach	leaving	right	left
0.25	2	2	¼	¼	¼	¼
0.50	1	1	¼	¼	¼	¼
0.75	2	2	¾	¾	¾	¾
1.00	1	1	½	½	½	½
1.25	2	2	1 ¼	1 ¼	1 ¼	1 ¼
1.50	1	1	¾	¾	¾	¾
1.75	2	2	1 ¾	1 ¾	1 ¾	1 ¾
2.00	½	½	½	½	½	½

The assessment of the coverage of sprayed objects was carried out using a computer graphic program. The contact point of the hydrophilic liquid was changed from yellow to dark blue. The degree of coverage was referred to as the ratio of the colored surface to the entire test surface. The analysis always included an equal area of 1 cm^2. The coverage rating was done in three randomly selected locations on the sampler.



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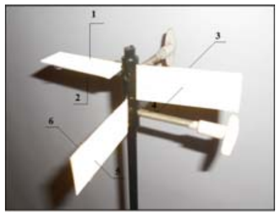


(b)

Fig. 2 View of an artificial plant: a – degree of coverage, b – deposition of liquid with marked researched facilities: 1 – horizontal top (A_{pog}), 2 – horizontal bottom (A_{pod}), 3 – vertical transverse leaving (A_{oj}), 4 – vertical transverse approach (A_{nj}), 5 – vertical longitudinal right (A_{bp}), 6 – vertical longitudinal left (A_{bl})

The degree of coverage at the variable coefficient of spray surface was obtained by multiplying the result on a particular sprayed object (expressed in % cm^{-2}) by its horizontal or vertical projection surface as shown in Table II.

TABLE II
SURFACE AREA OF HORIZONTAL AND VERTICAL PROJECTIONS FOR INDIVIDUAL COEFFICIENTS OF SPRAY SURFACES

Ratio of surfaces sprayed W_{po}	horizontal surfaces [cm^2]		vertical surfaces [cm^2]			
			transverse		longitudinal	
	top	bottom	approach	leaving	right	left
0.25	40	40	5	5	5	5
0.50	33.335	33.335	8.3325	8.3325	8.3325	8.3325
0.75	28.57	28.57	10.715	10.715	10.715	10.715
1.00	25	25	12.5	12.5	12.5	12.5
1.25	22.22	22.22	13.89	13.89	13.89	13.89
1.50	20	20	15	15	15	15
1.75	18.18	18.18	15.91	15.91	15.91	15.91
2.00	16.665	16.665	16.6675	16.6675	16.6675	16.6675

Appearance of the application liquid was evaluated on a PerkinElmer LS 55 luminescent fluorometer. To measure the concentration of the BSF marker, 30 ml of deionized water was first poured, then shaken for 15 minutes at a special shaking station of 162 cycles/min and shaking amplitude of 40 mm. Measurements were based on the BSF mark on the PerkinElmer LS 55 luminescent fluorometer.

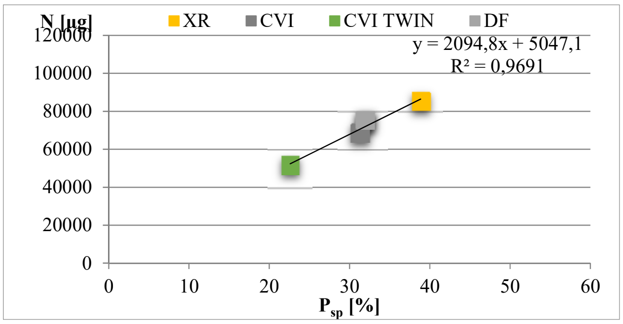
Deposition of liquid spraying at variable rate of spraying is the product of the concentration of the BSF on the sprayed object (expressed in µg · cm^{-2}) and its horizontal or vertical projection surface as shown in Table II.

In the experiments, there were four nozzles used; XR 11002, CVI 11002, CVI TWIN 11002, DF 12002, each with spraying speeds – 2.2 m·s^{-1}.

The relationship between application of liquid and the coverage of sprayed objects was determined by the linear regression method.

III. Results

The course of dependence between the degree of coverage of sprayed objects and deposition of liquid for different types of nozzles at selected spray surface coefficients and pressure 0.2 MPa is shown in Figs. 3-7. Due to the lack of surface coverage designated as the horizontal bottom, there is an omission of results related to the surface.



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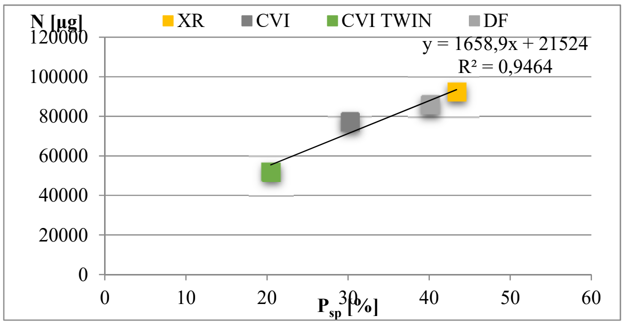

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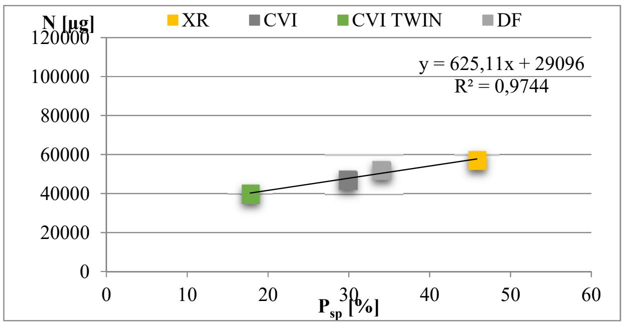

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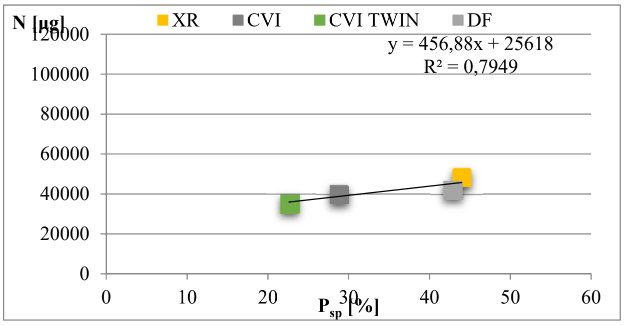

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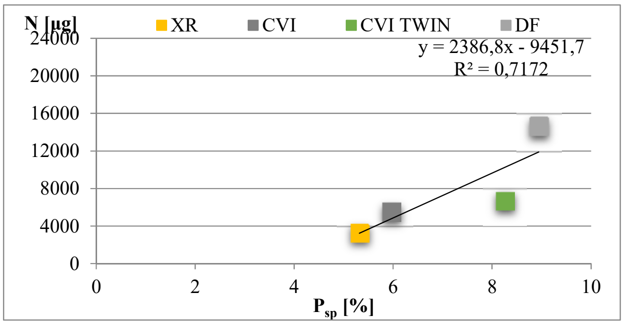
Fig. 3 The dependence of the deposition and degree of coverage on sprayed horizontal top objects at a pressure of 0.2 MPa for selected sprayers and spray surface coefficients (a-0.75, b-1, c-1.75, d-2)

By analyzing the graphs shown in Fig. 3, it can be seen that the amount of liquid deposition was clearly dependent on the degree of coverage. There was a very strong linear relationship between the application values and the coverage of sprayed top horizontal objects. The high value of R2 indicates a good fit of a simple regression to empirical data. While spraying the upper horizontal objects, the highest cover and deposition values were observed for XR single-stream nozzles, while the lowest for double-stream CVI TWIN nozzles, and each increase in coverage resulted in a strong increase in Wpo = 0.75 and 1, while in Wpo = 1, 75, and 2 increment was significantly worse (weaker).



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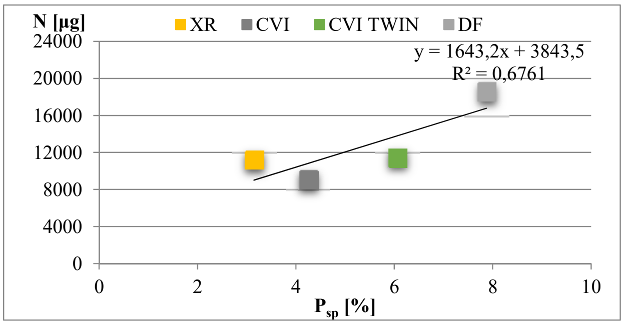

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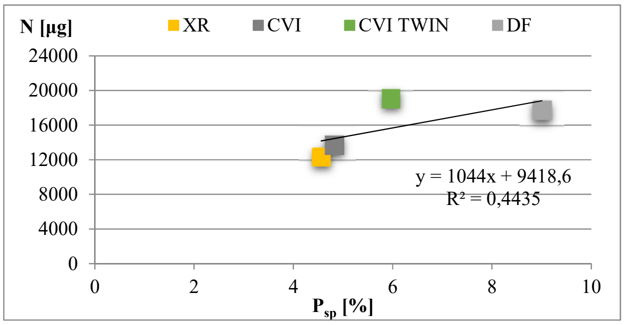

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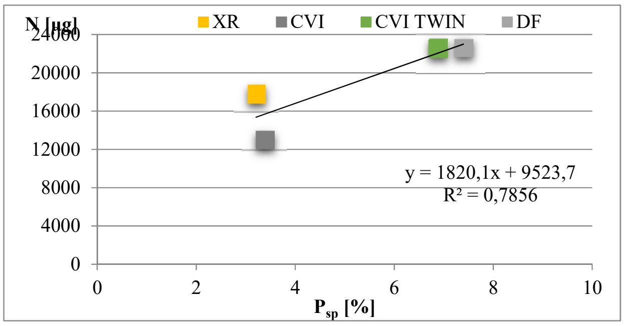

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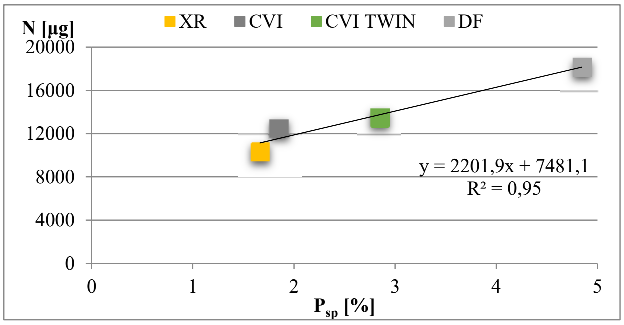
Fig. 4 The dependence of the deposition and degree of coverage on sprayed vertical approach at a pressure of 0.2 MPa for selected sprayers and spray surface coefficients (a-0.25, b-0.75, c-1, d-2)



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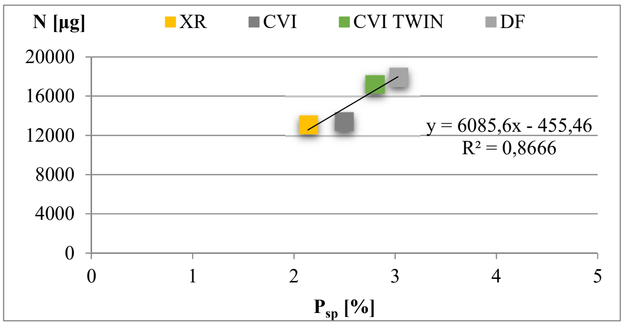

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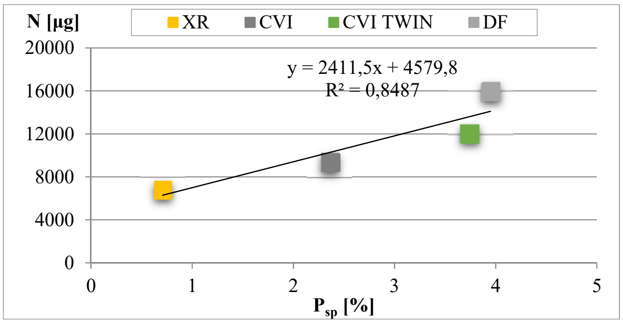
Fig. 5 The dependence of the deposition and degree of coverage on sprayed vertical leaving at a pressure of 0.2 MPa for selected sprayers and spray surface coefficients (a-0.50; b-0.75; c-1.50; d-1.75)



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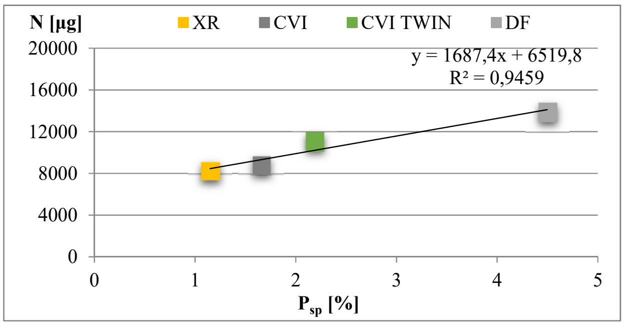

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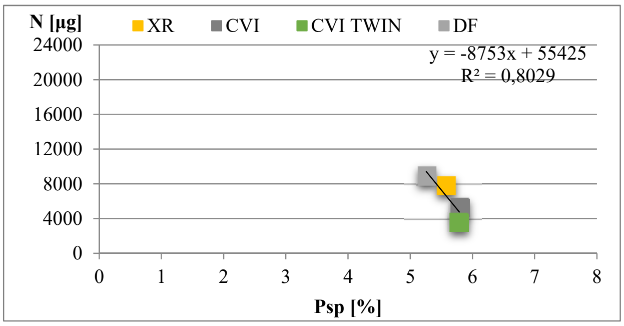
The dependence of the application on the sprayed vertical coverage on the approach and leaving at the specified spray surface coefficients is shown in Figs. 4 and 5. In case of analysis of all coefficients of the spray surface of vertical approach surfaces, a strong linear relationship between the values of the analyzed parameters was found, only at coefficient 1, the average relation was obtained while taking into account the dependence of the application on the cover of the vertical leaving objects, in all analyzed cases a very strong correlation was observed. Also in this case, the highest application values and coverage were recorded for double stream nozzles, while the lowest for single stream nozzles. Despite the significantly smaller range of deposition values coverage, the increase in coating coverage resulted in a strong increase in deposition.



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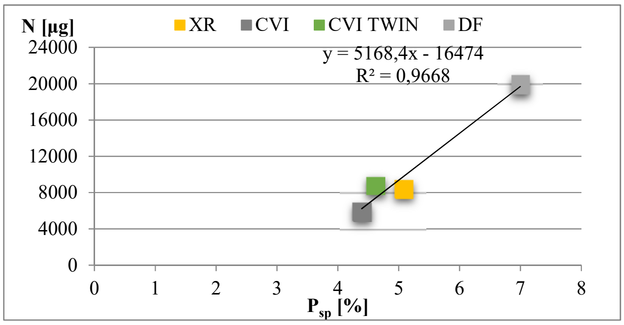

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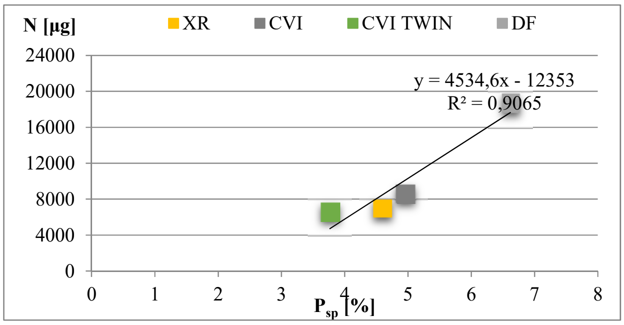

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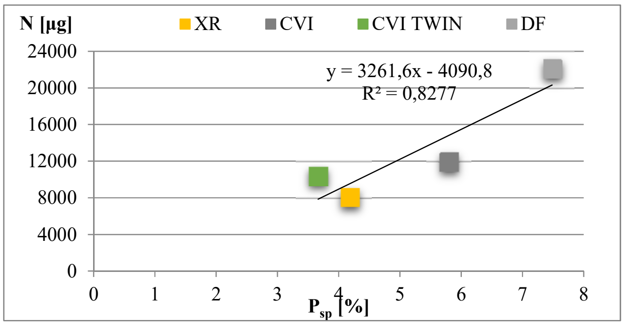
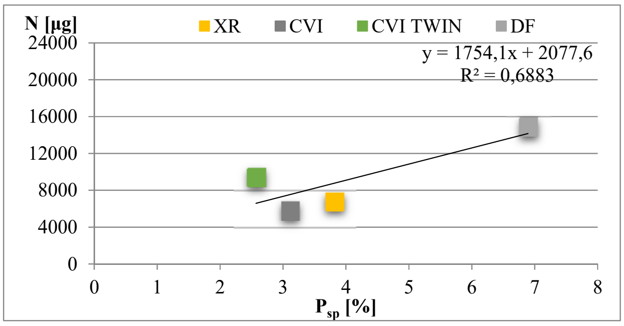


(d)

Fig. 6 The dependence of the deposition and degree of coverage on sprayed vertical right at a pressure of 0.2 MPa for selected sprayers and spray surface coefficients (a-0.25, b-0.75, c-1.25, d-1.75)

The dependence of the deposition on the coverage of sprayed right vertical objects is shown in Fig. 6 and the vertical left in Fig. 7. The values of the analyzed parameters are also very strongly correlated behind. The highest degree of correlation between coverage and application was obtained at coefficients of 0.75, 1.25, and 1.75, but with a Wpo of 0.25, a minimal decrease in the value of the application along with an increase in the degree of coverage was observed.

It should be noted that there is an exception to the rule, because the direction factors have a negative sign. In spite of the finding, in the majority of cases considered, a strong dependence between the coverage and application parameters in the right and left vertical objects was observed when the coverage was decreased with increasing cover. The explanation for this situation may be that the coverage range noted is too small to be less than the error of the method used in their determination.



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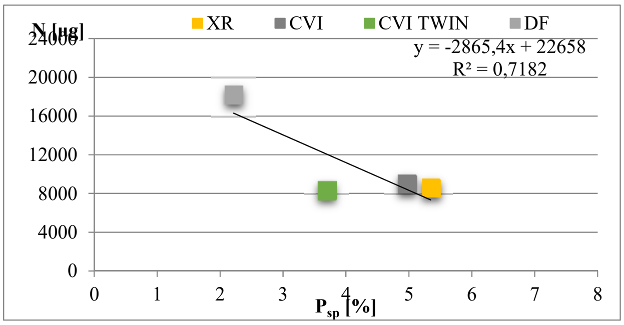

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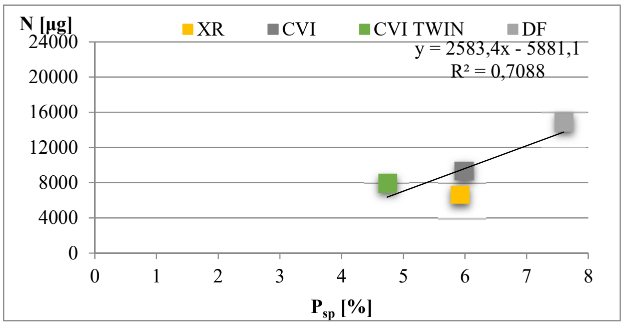

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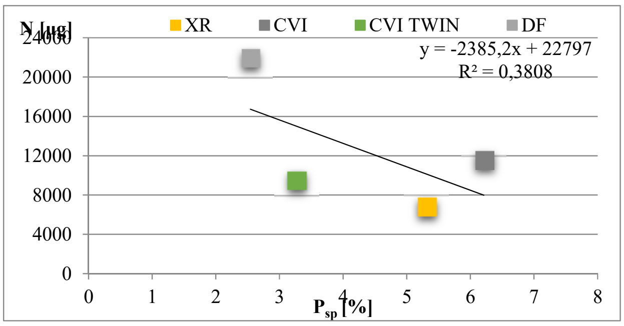

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Fig. 7 The dependence of the deposition and degree of coverage on sprayed vertical left at a pressure of 0.2 MPa for selected sprayers and spray surface coefficients (a-0.75; b-1; c-1.75; d-2)

IV. Conclusions

1. In assessing both the coverage and the application, there were large differences in the value of these indicators for spraying vertical and horizontal objects resulting from the use of different sprayers. The analysis of the results showed a much better coverage and deposition horizontal objects using standard single streamer nozzles as compared to double stream nozzles. On the other hand, when spraying vertical objects, better results were achieved using double stream nozzles.
2. Evaluation of the pattern of dependence on the degree of coverage of objects sprayed with linear regression showed very strong and strong correlation between these qualitative indicators of the procedure.

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