

COVERAGE OF THE SPRAYED OBJECTS IN THE ASPECT OF THE COEFFICIENT OF THE SPRAY SURFACES

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Abstract

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The aim of the study was to compare the degree of coverage of the sprayed objects with the selected nozzles in the aspect of the characteristics of the sprayed object, determined by the coefficient of the position of the sprayed surfaces. Studies were conducted in two stages, in laboratory conditions, in which the first step was to determine the characteristics of the sprayed objects, and in the second there were conducted the studies of the degree of coverage. Based on the analysis of the obtained results from the first stage it was stated that the studied plants were characterised by great differentiation of morphological features having a significant influence on the parameters of their spray characteristics. Important was the fact that the use of the coefficient of the spray surfaces W_{po} , determining the mutual relation of particular sprayed surfaces facilitates the selection of the most appropriate nozzles and treatment parameters in relation with the morphological features of the plant. In the second stage, concerning the studies of the degree of the coverage it was stated that the selected nozzles differed strongly in the degree of coverage of vertical and horizontal objects. Differentiated coverage for particular nozzles had a strong relationship with the coefficient of spray surfaces, except that the dual-spray nozzles covered the vertical surfaces better compared to the single-spray nozzles, which covered the horizontal surfaces better.

Keywords: degree of coverage, coefficient of the spray surfaces, nozzle, spraying

INTRODUCTION

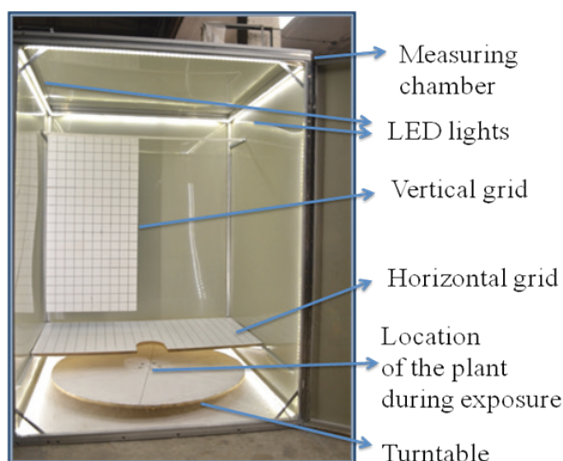
Plant protection is one of the most important branches of crop production, which makes it possible to prevent crop losses, resulting from threats connected with the harmful activity of pests. At the current stage of development of food production, moving away from the use of pesticides may cause the reduction of crops by approx. 70% (Pruszyński 2010). Pesticides, used in plant protection, as is well known, are often highly harmful substances. Often contradictory features and properties are often expected from them, namely:

- high toxicity to other pests,
- low toxicity to other living organisms,
- adequate durability,
- high susceptibility to degradation.

While from their users it is required to use them:

- where necessary,
- in such amount, which is necessary,
- without harming the environment and consumers.

As you can see, requirements for chemical plant protection are very high, difficult to meet and largely dependent on the quality of the performed plant protection treatments. The quality of the performed treatment decides, according to many authors, about the size and quality of the obtained crop (Nieróbca *et al.*, 2010). The most often used indicators to determine the quality of the performed spraying treatment are: the distribution of the precipitation of the sprayed liquid, the degree of coverage of the sprayed objects, application of the utility liquid (Nuyttens *et al.*, 2009; Özkan 2008; Szewczyk 2010; Szewczyk *et al.*, 2013). All of these



1: Scheme of the position for tests of the plant spray surface

indicators of the treatment quality depend on many technical conditions, technological conditions and meteorological conditions. None of the methods of determining quality indicators of the treatment so far has not included the characteristics of the sprayed object. According to the authors, taking this factor into consideration will allow the increase of the effectiveness of spraying, with the simultaneous limitation of the threat for the environment (Cieniawska 2014a, b).

The interest of researchers in the characteristics of plants is evidenced by many published literature positions. The issues raised in the article relate to, among others, determination of the photosynthetic surface of plants with the video-computer method (Kielbasa and Juliszewski 2005), the influence of the diversified nitrogen fertilisation on the yield and the influence of the chemical plant protection in conditions of various crop systems (Andruszczak *et al.*, 2012; Gołębiowska and Sekutowski, 2007). The experiments also apply to the indicator of the foliar state: LAI – leaf area and MTA – leaf inclination angle (Biskupski *et al.* 2007; Biskupski *et al.* 2009; Woźniak 2008). However, during the studies connected with the use of plant

protection means the authors' methods cannot be used, because they do not relate to the surface of projections. During the spraying, the application surfaces are "seen" by the nozzle as horizontal and vertical projections, which are the essential aim of the emitted droplets of the sprayed liquid.

Aim of the study

The aim of the study was to determine the influence of the spray surface coefficient on the degree of coverage of the sprayed objects using the selected single- and dual-spray nozzles.

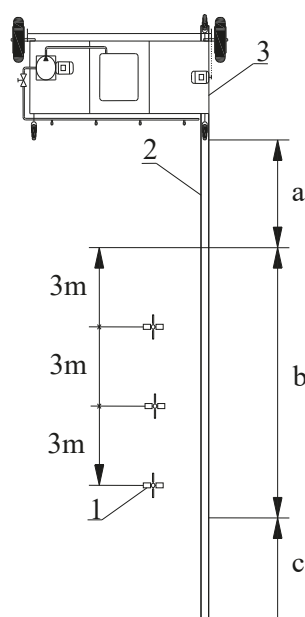
MATERIALS AND METHODS

First, as preliminary studies, there were performed experiments in the chamber to test the spray characteristics of plants. For the experiments there were selected five plants of alfalfa and rape in the shoot elongation phase. The position scheme is shown in Fig. 1.

The plant selected for the tests was placed in the measurement chamber, on the rotator. Then, there were taken the photos of the vertical and horizontal projections, rotating the dial and taking



2: Photos of horizontal projections of the studied plants



3: Scheme of the test position for the degree of coverage for the sprayed objects

1 – artificial plant, 2 – trajectory, 3 – nozzle carrier, a – acceleration section, b – measurement section, c – final section

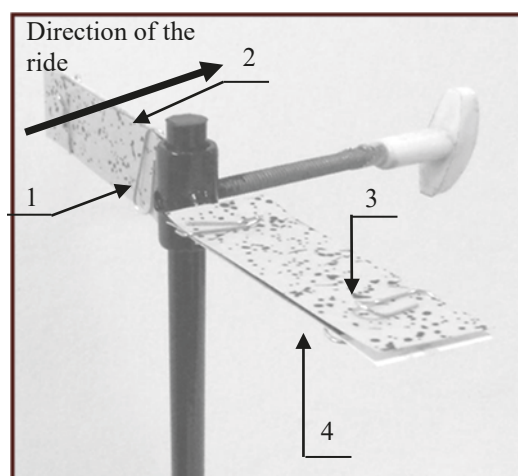
photos every 60°. The photos of the vertical and horizontal projections of plants were subjected to the graphic treatment in the program AutoCad 2011 (Fig. 2).

After obtaining the results of the graphic analysis in the program AutoCad 2011, there was calculated the coefficient of the spray surfaces. The formula, proposed by the authors, related to the ratio of the spray surfaces in the vertical and horizontal projection.

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

Following the model of the results of measurements obtained in the first step, in order to eliminate the external factors and to provide the repetition of the tests, in the second step, as the sprayed objects, there were used the artificial plants with such a structure to obtain the coefficient selected by the authors as $W_{po} = (0.50; 1; 1.50; 2)$. In the particular case of the given coefficient this resulted from the following system of the sprayed surfaces:

- 0.50–4 horizontal surfaces and 2 vertical surfaces,
- 1–2 horizontal surfaces and 2 vertical surfaces,
- 1.50–4 horizontal surfaces and 6 vertical surfaces,
- 2–2 horizontal surfaces and 4 vertical surfaces.



4: Photo of the artificial plant

1 – vertical overrun (A_{vj}), 2 – vertical stellar (A_{vj}), 3 – top horizontal (A_{pog}), 4 – bottom horizontal (A_{pod})

In the second step there were conducted the studies of the degree of coverage. The scheme of the experiment position is presented in Fig. 3. The key element of the position was the nozzle carrier, which worked as the self-propelled sprayer.

On the measurement section there were placed three artificial plants, representing three repetitions of the given measurement. To the artificial plants there were mounted probes in the form of water-sensitive papers, so they represent characteristic vertical and horizontal surfaces, and their number is represented by the coefficient of the spray surfaces (Fig. 4).

In the studies there were used the following standard and ejector nozzles: AXI 11002, CVI 11002, CVI TWIN 11002, AVI TWIN 11002. As the spray parameters there were adopted the following values: speed – $8 \text{ km} \cdot \text{h}^{-1}$, location of the nozzles in the longitudinal perpendicular plane to the surface – -10° , 0° , 10° , spray expense – $0.91 \text{ l} \cdot \text{min}^{-1}$ and the height of the nozzles – 0.5 m .

The degree of coverage was determined based on the computer analysis of the area. On the area

of the water-sensitive paper there were randomly selected three fragments of the surface of the $10 \times 10 \text{ mm}$ size. Then, using the formula, there was calculated the degree of coverage:

$$P_{sp} = \frac{W_k}{W_p} * 100 [\%],$$

where:

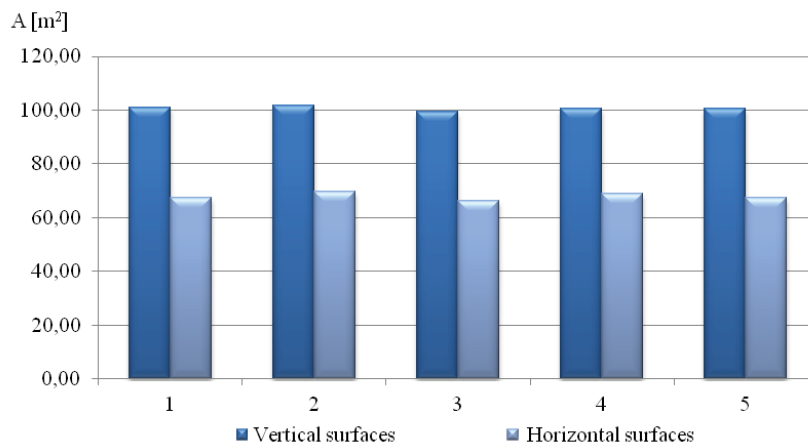
P_{sp} degree of coverage [%],

W_k surface covered with liquid [pixels],

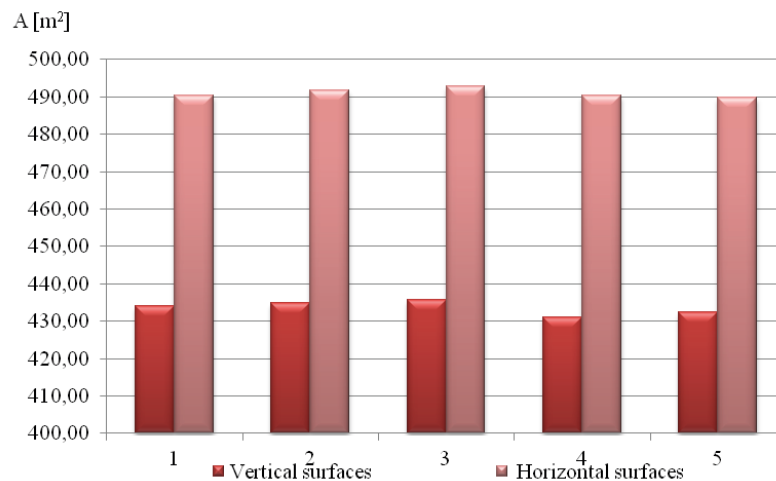
W_p surface of 1 cm^2 [pixels].

RESULTS AND DISCUSSION

Fig. 5 and 6 presents the results of measurements of the horizontal and vertical projections of the studied plants. The figures show five repetitions of the obtained results of the surface measurements for two types of plants, which substantially differ with morphological features. Alfalfa characterised by a greater surface of vertical projections, while rape in the phase of shoot elongation had a greater surface of horizontal projections.



5: Surfaces of horizontal and vertical projections of alfalfa



6: Surfaces of horizontal and vertical projections of rape in the phase of shoot elongation

I: Results of the coefficient of the location of spray surfaces

Alfalfa			Rape in phase elongation shoot		
Vertical surfaces	Horizontal surfaces	Wpo	Vertical surfaces	Horizontal surfaces	Wpo
101.08	67.25	1.50	434.04	490.25	0.89
101.75	69.50	1.46	434.96	491.75	0.88
99.58	66.25	1.50	435.67	492.75	0.88
100.42	68.75	1.46	431.08	490.25	0.88
100.42	67.25	1.49	432.29	489.75	0.88

Table 1 presents the values of the coefficient of the location of the spray surfaces.

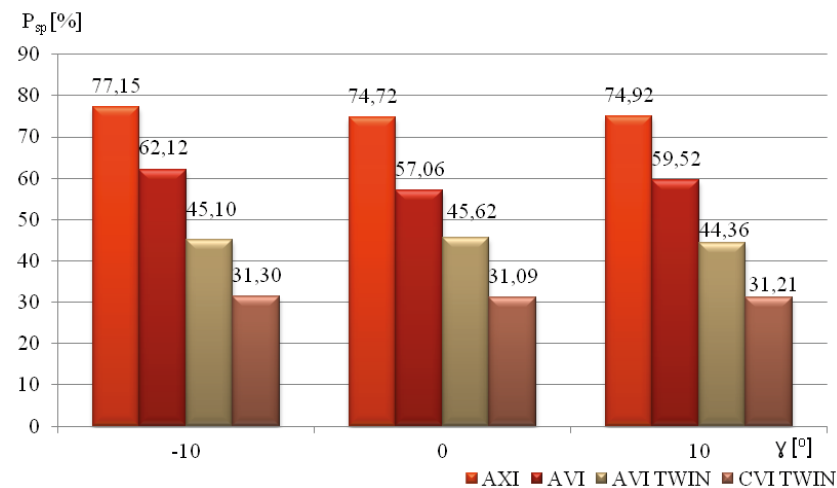
Alfalfa, for which the surface of vertical projections was greater than the surface of horizontal projections – therefore, the coefficient of the location of spray surfaces was greater than 1. While in case of rape in the phase of shoot elongation, which surface of vertical projections was smaller than the surface of horizontal projections – this coefficient was smaller than 1.

Coefficients of the spray surfaces presented in Tab. I calculated based on the conducted

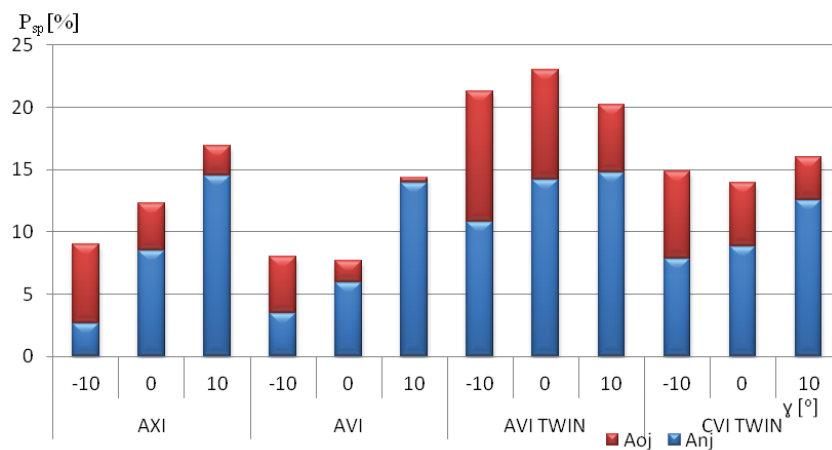
measurements were discussed by the authors in publication on their usefulness in plant protection technology (Cieniawska *et al.*, 2014a, b).

Results of the studies of the degree of coverage are presented in diagrams (Fig. 7 and 8).

Fig. 7 shows the results of studies of the degree of coverage of the sprayed horizontal objects. The degree of coverage of these surfaces was the highest in the application of the single-spray nozzles AXI and AVI: In contrast to the dual-spray nozzles AVI TWIN and CVI TWIN, for which there was noted the lowest degree of coverage:



7: Degree of coverage of top horizontal objects



8: Degree of coverage of vertical objects

II: Results of the multivariate variance analysis

Factor	Value of the test function F	Value of the probability level p
Nozzle	10.6018	0.0000
Surface	295.7085	0.0000
The angle of the nozzle	0.1141	0.8923

III: Results of the statistical analysis Post-hoc

Surface	{1} 52.848	{2} 9.8275	{3} 4.9636
Apog		0.0000	0.0000
Anj	0.0000		0.0270
Aoj	0.0000	0.0270	

For each setting of the nozzle in the longitudinal perpendicular plane to the surface both in the direction of driving and the opposite one.

Fig. 8 shows the test results of the degree of coverage of the vertical overrun and stellar objects. In this case dual-spray nozzles have a better coverage of both vertical surfaces compared to the single-spray nozzles. It was also interesting that the degree of coverage increased with the nozzle deflection in the direction of driving:

During all measurements conducted during the studies there were not stated any traces of coverage of the bottom horizontal objects.

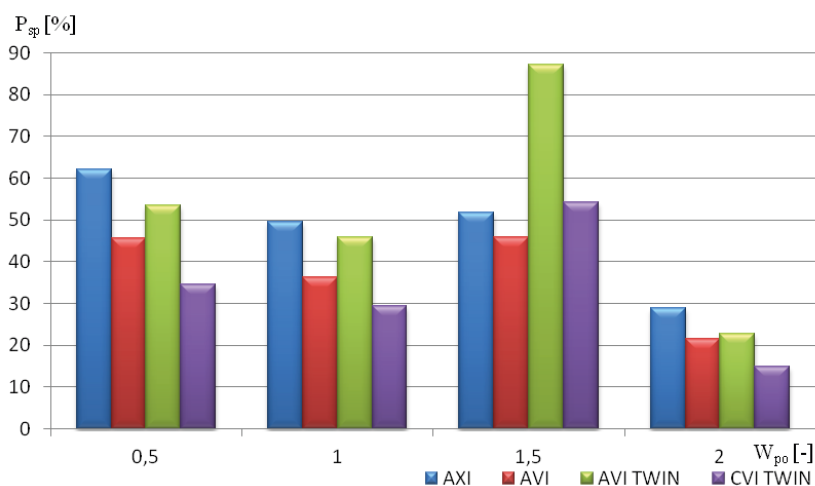
For the statistical study of the test results there was used the multivariate analysis of variance, which results are presented in Tab. II and the statistical analysis Post-hoc, which results can be found in Tab. III.

From the presented data of the statistical analysis it results that the studied factors had a significant influence (at the level of $\alpha = 0,05$) on the degree of coverage of the studied objects, except for the lack of significance of the influence of the nozzle setting (Tab. II).

From the statistical analysis Post-hoc results that in case of every sprayed surface there are significant differences in the degrees of coverage.

Interpretation of the obtained results is in line with what is emphasized by many researchers in their publications in connection with the importance of the selection of the right nozzle for the treatment as an important factor of quality of the work performed during the plant protection treatments both in the field and horticultural conditions and in the crops under covers (Guler *et al.*, 2007).

Fig. 9 presents the average degree of coverage depending on the coefficient of the location of spray surfaces. In case of plants, for which the coefficient of location of spray surfaces is smaller than 1, (predominance of horizontal surfaces), the studied surfaces will have a better coverage with liquid with the single-spray nozzle. While in case of dual-spray nozzles, a better coverage was stated in plants characterised by the coefficient W_{po} greater than unity.



9: Average degree of coverage depending on the coefficient of the location of spray surfaces

CONCLUSION

Nozzles used for the studies were characterised by the different ability of spraying the vertical and horizontal objects. Dual-spray nozzles had a better coverage of the vertical surfaces in contrast to the single-spray nozzles, with a better coverage of horizontal surfaces.

Plants selected for the studies were characterised by the great differentiation of morphological features determining their spray characteristics, i.e., the surface of the horizontal projection, the surface of the vertical projection and the general surface of exposure to the spray.

The analysis of the obtained test results indicates that the application of the coefficient of the spray surfaces W_{po} , determining the mutual relation of particular sprayed surfaces facilitates the selection of the most appropriate nozzles and the treatment parameters depending on the morphological features of the sprayed plants.

The multivariate analysis of variance showed a significant effect, at the significance level of $\alpha = 0,05$, of the applied nozzle and the location of the sprayed surface on the degree of coverage, except for the lack of significance of the influence of the nozzle location in the longitudinal surface, perpendicular to the surface.

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