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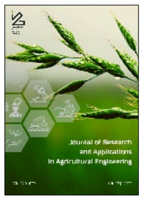

Evaluation of the Quality of the Spray Treatment in Terms of Average Degree of Coverage and Coverage Unevenness Coefficient

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The purpose of the study was to determine the effect of driving speed and liquid pressure on the average coverage rate and unevenness coefficient using selected standard and air induction flat fan nozzles. The study was conducted using a spraying device that functioned like a self-propelled sprayer. Based on the test results, it was found that the highest average coverage was obtained for single standard flat fan nozzles. On the other hand, greater uniformity was observed with standard nozzles at 0.4 MPa.
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1. Introduction

The quality of spraying in agricultural practices is critical for ensuring effective pest control while minimising environmental impact. The degree of coverage, which refers to how well the spray is distributed over the target area, is a key factor in determining the quality of spraying. Effective coverage ensures that pesticides reach the intended areas, reducing the need for excessive chemical use and minimising off-target drift.

Several studies have explored the factors affecting the degree of coverage. For instance, the correlation between droplet size, liquid pressure, and nozzle type has been shown to strongly correlate with the degree of coverage and deposition of spray liquids. High Pearson's correlation coefficients indicate a strong relationship between these factors and the degree of coverage, with linear regression models showing a good fit to empirical data [2].

The type of nozzle and operational conditions such as spray pressure, driving speed, and spray angle also play a pivotal role. Research has demonstrated that single and dual flat-fan nozzles can achieve high average coverage, although they may also result in uneven coverage. Adjusting droplet size and operational parameters can help optimise coverage while minimising unevenness [3]. In vineyard applications, the positioning of nozzles and the pressure used can affect coverage, with optimal results often achieved at specific heights and pressures. This highlights the importance of precision in nozzle placement and pressure settings to maximise coverage and reduce chemical use [10].

Moreover, machine learning models have been used to evaluate technical factors affecting spray coverage, highlighting the importance of nozzle type and spraying norms in achieving greater area coverage and reducing drift [11]. Additionally, the uniformity of spray liquid coverage is essential for reducing pesticide use and ensuring environmental safety, necessitating the development of new models for better prediction and assessment of spray processes [7]. The choice of nozzle and spray quality also plays a significant role in coverage. Coarser sprays have been found to reduce drift while maintaining effective canopy penetration, which is crucial for pest control in dense crop canopies [6]. Furthermore, precision spraying technologies, such as profile variable rate spraying, have been developed to enhance coverage efficiency and reduce environmental pollution by adjusting spray parameters based on canopy characteristics [8].

Overall, improving the quality of spraying through better coverage not only enhances pest control efficacy but also supports sustainable agricultural practices by reducing chemical usage and environmental impact. Continued research and technological advancements are essential for optimising spray coverage and ensuring the rational use of pesticides in agriculture.

The purpose of research was to determine the impact of the type of the single flat fan nozzles, liquid pressure, and driving speed on the average degree of coverage and coverage unevenness coefficient.

2. Materials and methods

The experiments were conducted on a strawberry plantation. Two 50-metre rows were selected for the study, with each row divided into 10-metre sections. Treatments were applied from the onset of fruit ripening (BBCH phenological stage 81) on four dates: 30th May, 6th June, 14th June, and 22nd June. The atmospheric conditions prevailing during the experiments are summarised in Table 1.

The spraying equipment functioned as a self-propelled sprayer. Two types of single flat fan nozzles were selected for the study: standard and air-induction nozzles. Standard nozzles are used under optimal weather conditions, while air-induction nozzles are applied during treatments conducted in less favourable atmospheric conditions.

The following operating parameters of the nozzles were applied during the study:

- Pressure: 0.2 and 0.4 MPa,
- Nozzle working height: 0.5 m,
- Travel speed: 5 and 10 km·h^{-1}.

During the passage of the spraying equipment, three artificial plants with attached water-sensitive papers (76 mm × 26 mm, Syngenta Crop Protection AG, Basel, Switzerland) were placed within the experimental plot to capture horizontal and vertical surfaces. During spraying, the nozzles mounted on the boom are positioned vertically, perpendicular to the ground. This configuration results in spray liquid being deposited on both vertical and horizontal surfaces. Water-sensitive papers were positioned on artificial plant to represent the following surfaces: vertical approach (1), vertical leaving (2), horizontal upper (3), and horizontal lower (4) (Fig. 1). The use of artificial plants was intended to minimise variations in leaf positioning caused by atmospheric wind or apparent wind generated by the movement of the equipment.

After spraying, the water-sensitive papers were removed from the artificial plants and secured to protect them from moisture. The degree of coverage of the sprayed areas was determined by computer image analysis following scanning.

Table 1. Atmospheric conditions measured during the survey

Date	Temperature [°C]	Wind Speed [m·s^{-1}]	Air Humidity [%]
30.05.2022	17	1.7-2.0	70
6.06.2022	21	0.5–0.6	65
14.06.2022	23	0.5–0.6	62
22.06.2022	23	0.3	62

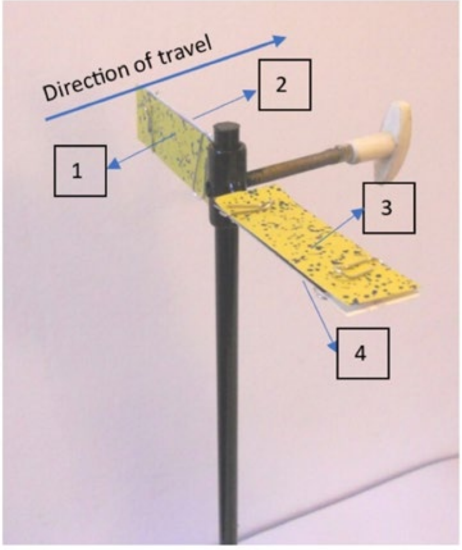

Fig. 1. The positioning of water-sensitive papers on the artificial plant was determined by the sprayed surfaces and the direction of travel

The degree of coverage was calculated as the ratio of the area covered by the spray liquid to the total surface area of the sampler.

$$P_{sp} = A_{pc} \cdot A_p^{-1} \cdot 100\ [\%] \qquad (1)$$

where: Psp — degree of coverage (%), Apc — area covered by the spray liquid (pixels), Ap — total surface area of the sampler (pixels).

The average degree of coverage was calculated as follows

$$\chi P_{sp} = (P_{spg} + P_{spn} + P_{spo}) \cdot n^{-1} [\%] \qquad (2)$$

Where 〖χP〗_sp - average degree of coverage; Pspg - average degree of coverage of the upper horizontal surface (%); Pspn - average degree of coverage of the vertical approach surface (%); Pspo - average degree of coverage of the vertical leaving surface (%); n - number of tests.

During the experiments, the lower horizontal surface was not covered with liquid in any of the tests. Therefore, this surface was not considered for further analysis.

The coverage uneveness coeficcient was calculated from equation (3) according to the formula:

$$\eta = \frac{\sqrt{\frac{1}{n-1} \cdot \sum_{i=1}^{n} (P_{spi} - \chi P_{sp})^2}}{n} [\text{-}] \qquad (3)$$

where η - coverage uneveness coeficcient (-); Pspi - coverage of individual surfaces; χPsp – average degree of coverage of all surfaces; n - number of tests.

3. Results and discussion

The results of the average degree of coverage are shown in Figure 2-3, while the results of the unevenness ratio are presented in Figure 4-5. Considering the values of average degree of coverage, it should be concluded that both liquid pressure and driving speed affect this parameter. Higher values of average degree of coverage were measured for nozzles at higher liquid pressure.

The results of the coverage uneveness coefficients are shown in Figures 4-5. In most cases, the treatments that were carried out with a liquid pressure of 0.4 MPa had lower values of this parameter. Thus, they provided greater uniformity.

The results of the average degree of coverage study were conducted in both field and orchard crops. Qin et al. found that the average degree of coverage is influenced, among other things, by the height of the boom setting, the type of sprayer and the angle of the nozzles [9]. On the other hand, Dereń et al. presented comparative results of single- and dual flat fan nozzles. On the basis of the study, the authors showed that higher values were obtained for dual flat fan nozzles [4]. On the other hand, Bolat et al. and Drocas et al. found that the average coverage rate is influenced by the type of nozzle used, the speed of the sprayer and the pressure of the liquid [1, 5]. The results of these studies correlate with the results presented in this paper.

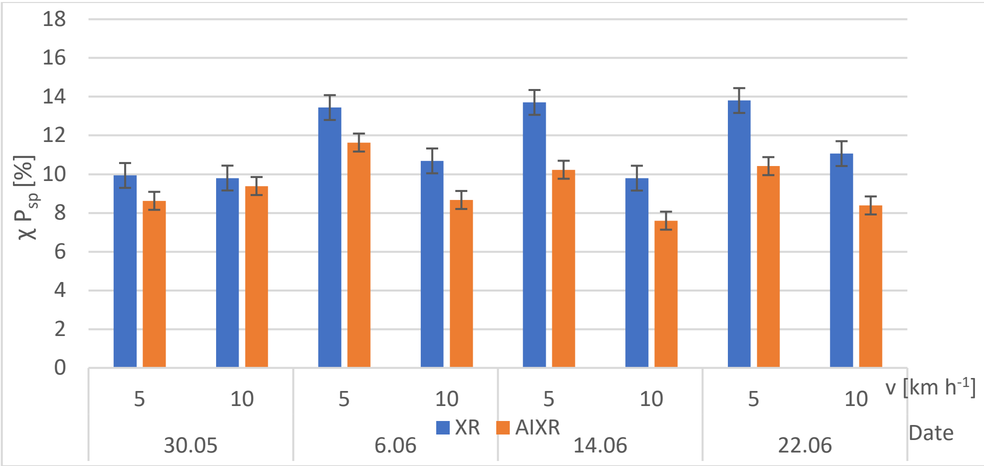

Fig. 2. Average degree of coverage for selected nozzles at 0.2 MPa

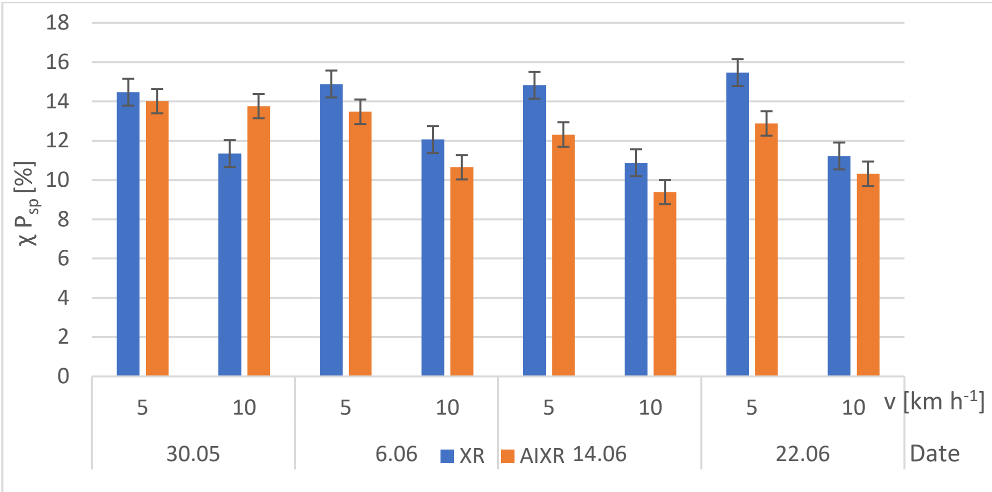

Fig. 3. Average degree of coverage for selected nozzles at 0.4 MPa

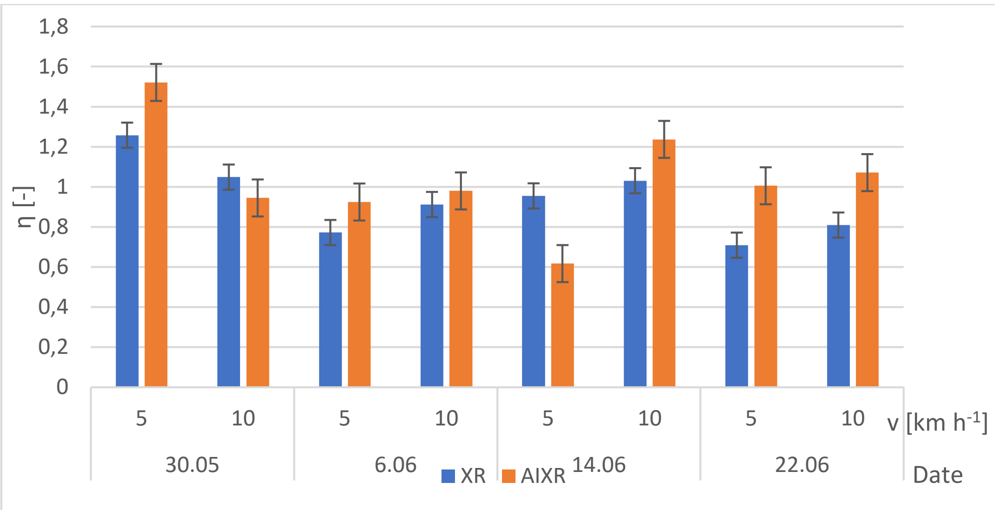

Fig. 4. Coverage uneveness coeficcient for selected nozzles at 0.2 MPa

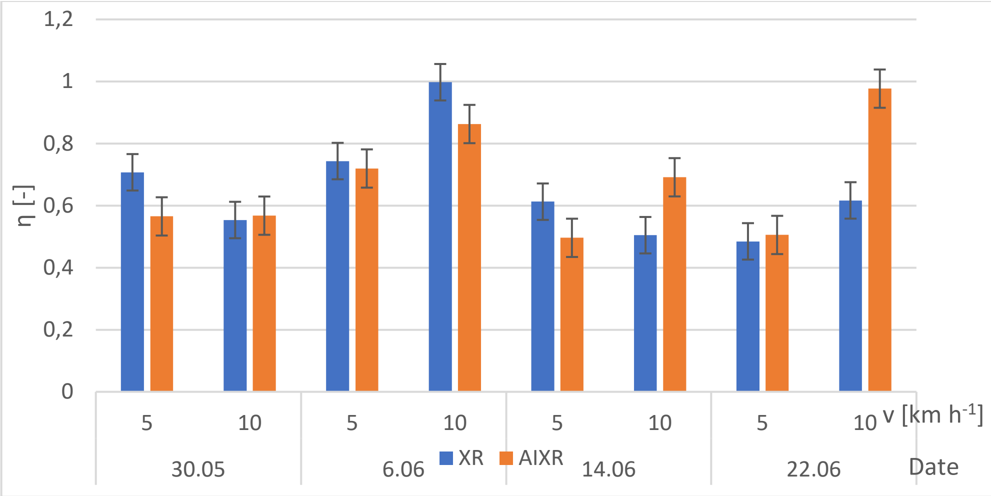

Fig. 5. Coverage uneveness coeficcient for selected nozzles at 0.4 MPa

4. Conclusions

The research results presented in this paper provide practical information on nozzle selection and parameters. This is to ensure the highest uniformity with the highest average liquid coverage. Higher uniformity was characterised by air induction nozzles. Conversely, higher values for average coverage were obtained for standard nozzles.

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