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Araştırma Makalesi / Research Article

# Optimization of Spray Characteristics of Full Cone Nozzles Used in Pesticide Application Using the Taguchi Method

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**Abstract**

The present study aims to reduce the amount of pesticide that can be released into environment, soil, air, and water by minimizing the type of nozzle and the use of excess pesticides by making use of the Taguchi method. For this purpose, studies were carried out to determine the spray characteristics of the pesticide. The sodium fluorescein was used in the experiments. In this study, the effects of the nozzle-to-surface distance (spray height), spray pressure, nozzle orifice diameter, and nozzle position angle on the droplet diameter and flow characteristics were investigated using the Taguchi method. The mean diameter values were determined first. Then, the volumetric median diameter (VMD) was considered as performance parameter and $L_9(3^4)$ orthogonal sequence was chosen as the experimental plan for four parameters that were determined. Calculating the VMD considered as the performance characteristics, optimum results were obtained using 6 bar spray pressure, 100 mm spray height, 30º nozzle position angle, and 1.10 mm nozzle orifice diameter. The VMD values were calculated using the image processing method and the effects of the parameters on the droplet diameter were interpreted using charts.

**Keywords:** Pesticide application, Spray optimization, Spray characteristics, Taguchi method.

# Pestisit Uygulamalarında Kullanılan İçi Dolu Konik Hüzmeli Memelerin Püskürtme Karakteristiklerinin Taguchi Metoduyla Optimizasyonu

**Öz**

Bu çalışmada, Taguchi yöntemi kullanılarak minimum ilaç kalıntısını sağlayan meme tipini ve fazla ilaç kullanımını en aza indirerek çevreye, toprağa, havaya ve suya karışabilecek ilaç miktarının düşürülmesi amaçlanmıştır. Bu amaç doğrultusunda bitkisel ilaçlamada püskürtme özelliklerinin belirlenmesine yönelik deneysel çalışma yapılmıştır. Deneylerde sodyum fluorescein kullanılmıştır. Çalışmada püskürtme uygulamalarını değerlendirmek üzere dikey dizilmiş suya duyarlı kağıtlardan oluşan deney düzeneğinde, meme-yüzey arası mesafe (püskürtme yüksekliği), püskürtme basıncı, meme orifis çapı ve meme konum açısının damlacık çapı ve akım karakteristiklerine etkileri Taguchi yöntemi kullanılarak incelenmiştir. İlk aşamada ortalama çap değerleri belirlenmiştir. Hacimsel medyan çap (HMD) performans karakteristiği olarak dikkate alınmış ve belirlenen dört parametre için $L_9(3^4)$ ortogonal dizisi deney planı olarak seçilmiştir. Performans karakteristiği dikkate alınarak HMD hesaplandığında optimum sonuçlar; 6 bar püskürtme basıncı 100 cm püskürtme yüksekliği, 30º meme konum açısı ve 1.10 mm meme orifis çapında elde edilmiştir. HMD değerleri görüntü işleme yöntemiyle hesaplanmış, parametrelerin damlacık çapı üzerindeki etkileri grafiklerle yorumlanmıştır.

**Anahtar Kelimeler:** Pestisit ilaçlama, Püskürtmenin optimizasyonu, Püskürtme karakteristikleri, Taguchi metodu.

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NOMENCLATURE

| | | | |
|---|---|---|---|
| $d$ | nozzle diameter | $n_r$ | number of repetitions in confirmation experiment |
| $D_{10}$ | arithmetic mean diameter | $N$ | the total number of experiments |
| $D_{20}$ | surface mean diameter | $P_s$ | spraying pressure |
| $D_{30}$ | volumetric mean diameter | $S/N$ | signal to noise ratio |
| $D_{32}$ | sauter mean diameter | $r_1$ | droplet homogeneity |
| $D_{min}$ | the smallest measured diameter value | $r_2$ | droplet homogeneity coefficient |
| $D_{max}$ | the largest measured diameter value | *WSP* | water sensitive paper |
| $D_{V0.5}$, *VMD* | volumetric median diameter | $Xi$ | fixed effect of parameter level *i*th experiment |
| $D_{N0.5}$ | numerical median diameter | $Yi$ | performance value of the *i*th experiment |
| $e_i$ | random error | $Z_B$, $Z_K$ | performance statistic |
| $F_\alpha$ | F table value | $\mu$ | overall mean performance value |
| $H$ | spray height | $\alpha$ | Nozzle angle |
| $H$ | nozzle to surface distance (from the tip of the fin to the nozzle) | $\Omega$ *(db)* | Decibel value of percentage subject to omega transformation |
| $m$ | degrees of freedom used in the prediction of $Yi$ | *DF* | degree of freedom |
| *MSe* | mean square error | *Exp.* | experiment |
| $n$ | number of repetitions done for an experimental combination | *rep* | repetition |

## 1. Introduction

Modification of the production factors is a must in order to increase the efficiency in agricultural production. From this aspect, agricultural pesticides constitute the most important expense item. Thanks to their rapid effects on agricultural production, chemical pesticides sprayed in liquid form by using agricultural instruments that are called “sprayer” (sometimes atomizer) are widely used for eliminating the agricultural pests (Gunel & Ozturk, 2006; Sayinci et al., 2019).

When working with pulverizers, many factors affect the formation of the droplets, transportation of droplets to target, and adhesion of active substances on the surface. The factors influencing the performance of the chemical agent include structural characteristics including the nozzle type, the orifice size, spraying angle, position angle, spraying height, and the distance between nozzles, engineering parameters related with air velocity and direction for sprayer units with auxiliary airflow systems, application capacity, operational parameters related with application rate, spraying pressure, and pace of progression, the meteorological factors related with air temperature, air humidity, wind velocity, and wind direction at the moment of pesticide application, plant characteristics related with plant height, leaf surface characteristics, and leaf surface index, physical characteristics related with viscosity, volume, and temperature of liquid being sprayed (Hoffmann & Salyani, 1996; Panneton et al., 2000; Zhu et al., 2002; Bayat & Bozdogan, 2005).

The strong interaction between these factors makes the application of pesticides difficult. Therefore, the application method should be analyzed carefully.

In their study, Cetin et al. (2019) compared the differences between the spray angle values determined both image processing and manually at 3 bar spray pressure and claimed that they achieved the results that are close the nominal angle values. Although there had no any nominal angle values for full cone nozzles. However, it was reported in their study that the spray angle increased with increasing orifice diameter.

In the study performed by Minov et al. (2014), the researchers determined the distribution uniformity of five different hydraulic nozzles (Albuz ATR orange and red, Teejet XR 11001, XR 11004, and Al 11004) with different operating characteristics using a patternator with 3 cm intervals and a slope of 5%. In that study, the spraying heights for different groups were set as 15 cm, 30 cm, and 50 cm, and the spray applications were carried out at 4, 6, and 8 bar pressure. The analyses have revealed that the boom height significantly influenced the spray pattern of the nozzles.

In a study performed by Višacki et al. (2016), volumetric distribution uniformity (CV%) of the standard, air-suction, and double-flow fan nozzles with standard nozzle orifice sizes of 120-04 were defined for different spraying heights (40, 50, and 60 cm) and operating pressures (200, 250, 300, 350, 400 and 450 kPa). Not only it was stated that the volumetric distribution improved as the spray height increased, but it was also determined that CV% tended to increase as the operating pressure increased in the air suction nozzle.

Bretthauer et al. (2011), evaluated the spraying solutions according to their droplet size, weed control capacity when sprayed using Turbo TeeJet nozzle, Turbo Drip Twin Fan nozzle, Air Induction Extended Range nozzle, Turbo TeeJet Induction nozzle, Turbo TwinJet nozzle, and Small Volume Sprayer Turbo nozzle. The results indicated that the droplet diameter varied according to the type of nozzle.

In their laboratory studies, Foque and Nuyttens (2011) tested the effects of air support and spray angle (-30 °, 0 °, 30 °) on the spray deposition. The spray deposition was measured using a large droplet spray nozzle (Lechler ID 90 02 at 6,0 bar) and was subjected to visual assessment using a quantitative method and water-sensitive paper.

In their study, Castanet et al. (2013) presented the development stages of an optical technique aimed at simultaneously measuring the droplet size and velocity. This technique relied on shadow plotting associated with high-speed imaging. This method was used to investigate the effects of droplets in a heated maxima above the Leidenfrost temperature (Leidenfost effect). Image analysis involved detecting droplet outlines to measure their size and tracking droplet trajectories to determine their velocity. The study also presented different steps of image processing. The researchers stated that this method was employed to address problems specific to the effect of turbid, deformed, and overlapping droplets depending on the magnitude of their depth.

Sun et al. (2017) developed a measurement system to measure droplet sizes in the field. Droplet characteristics, including reflectance field, diameter, and volume, were determined using MATLAB image processing technology. Internal comparisons were conducted between the developed system and the oil disc method and the mean margins were found to be 6.03% for $D_{V0.1}$, 5.50% for $D_{V0.5}$, and 6.25% for $D_{V0.9}$.

In the present study, it was aimed to optimize the flow characteristics of effective droplet diameter by using the Taguchi method to reduce the amount of pesticide that will be released into the environment, soil, air, and water and to minimize the excessive use of chemical agents while struggling with plant pests. For this purpose, the parameters affecting the flow characteristic were determined to be nozzle diameter, distance between nozzle and target surface, spraying pressure, and spraying angle.

## 2. Materials and Methods

### 2.1. Experimental parameters and planning

In order to reach a correct result in experimental studies, it is necessary to make a correct experimental design, determine the parameters correctly and know exactly what to expect from the test result. Even if all these conditions are met, it may be necessary to perform a large number of the same sample or the same experiment in order to achieve an accurate and desired target.

The experimental setup used in experiments is illustrated in Figure 1. The experiments were conducted under controlled conditions and the effects of weather conditions were minimized. In the experimental system, the spraying ground was made of a 2 mm stainless steel sheet. The experimental setup has 0.5 × 5 m dimensions and a height of 2 m. The target surface model was manufactured from wooden material and has a height of 220 cm. Fifteen water-sensitive papers (WSP, 28 × 38 mm) were placed on the vertical plane of the model in a single row with 2 cm intervals. The sodium fluorescein was used in the experiments. The spraying rate was measured, and the experiments were carried out with a constant spraying rate of conveyer speed (1.2 m/s). Movement in the system was driven by a linear motion mechanism consisting of an electric motor and a reducer. Furthermore, a mechanical fixing device was placed on the movable mechanism to adjust the nozzle position angle. A tank having the shape of rectangular prism was manufactured in order to store the fluid in the system. Homogeneous distribution in the tank was achieved with the help of a mixer. The pressure of the fluid was controlled by a regulator located at the pump outlet. Automation of the system was ensured by making use of fluid pressure, which was measured using a manometer. During the experiments, protective flexible sheaths were used in order to prevent any damage to the pipes conveying the fluid.

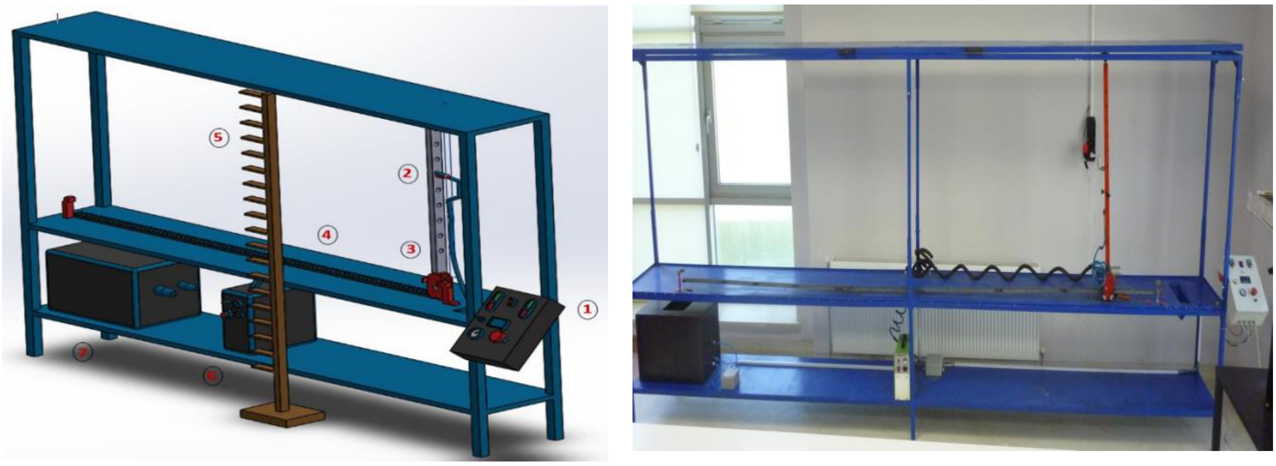

**Figure 1.** Experimental setup design
(1) Spraying Control Unit, (2) Nozzle, (3) Height and Angle Adjustment Mechanism for Nozzle, (4) Rack Gear, (5) Target Surface Model, (6) Pump, (7) Tank

Determination of optimum parameters with the Taguchi method is done as follows;

- The outcome variable is determined.
- Variable parameters (factors) that affect the result are determined.
- Levels of variable parameters are determined.
- Appropriate experimental design is selected.
- Experiments are carried out.
- Model evaluation is made based on the results.
- With variance analysis, the accuracy of the model is tested and the effect ratios of the parameters are determined.
- Optimum parameters and their values are determined. (Ozturk et al., 2023)


**Figure 2.** Fully conical jet nozzles.

**Table 1.** Parameters examined in the study and their values.

| Parameters | | 1 | 2 | 3 |
|---|---|---|---|---|
| A | Spraying pressure, $P_s$ [bar] | 6 | 8 | 10 |
| B | Spraying height, H [mm] | 70 | 85 | 100 |
| C | Nozzle angle, α [degree] | 0 | 15 | 30 |
| D | Nozzle orifice diameter, d [mm] | 0.85 | 1.1 | 1.5 |

As can be seen, all parameters were represented with three different levels and, accordingly, $L_9(3^4)$ orthogonal sequence given in Table 2 was chosen as the experiment plan (Phadke 1989).

**Table 2.** Parameters examined in the study and their values.

| | **Parameters** | | | |
|---|---|---|---|---|
| ***Exp.*** | ***A*** | ***B*** | ***C*** | ***D*** |
| ***1*** | 1 | 1 | 1 | 1 |
| ***2*** | 1 | 2 | 2 | 2 |
| ***3*** | 1 | 3 | 3 | 3 |
| ***4*** | 2 | 1 | 2 | 3 |
| ***5*** | 2 | 2 | 3 | 1 |
| ***6*** | 2 | 3 | 1 | 2 |
| ***7*** | 3 | 1 | 3 | 2 |
| ***8*** | 3 | 2 | 1 | 3 |
| ***9*** | 3 | 3 | 2 | 1 |

Instead of carrying out $3^4 = 81$ experiments with the full factorial design, $L_9(3^4)$ experiment plan was implemented using Taguchi experiment design and 18 experiments were carried out by conditioning only 9 experiments. To observe the effects of disruptive and random factors in the experiments, each experiment was repeated twice at different times. “Performance statistics” was chosen as the optimization criterion. Performance parameters of the droplet diameter were computed in order to analyze the effects of the parameters on optimization criteria. Droplet diameter was calculated by using the total atomization surface area, which was obtained using the image processing technique that was based on the software created as a result of special development. The results obtained showed that the general optimum conditions were found. "The smaller the better" performance statistics were used for the droplet diameter.

The full cone nozzles made in stainless steel, which are widely preferred in garden sprayers, were used in spray application. The nozzles having 0.85 mm, 1.1 mm, and 1.5 mm orifice diameters were selected for the experiments (Figure 2).

In this study, WSP samples were scanned, and droplet diameters and homogeneity values were determined by using the image processing method. The selected controllable parameters that were considered to have effect on flow characteristics and the results are shown in Table 1.

$$Z_B = -10Log\left[\frac{1}{n}\sum_{i=1}^{n}\frac{1}{Y_i^2}\right] \quad (1)$$

and developed for “the smaller the better" situation:

$$Z_K = -10Log\left[\frac{1}{n}\sum_{i=1}^{n}\frac{1}{Y_i^2}\right] \quad (2)$$

are the two of the optimization criteria alternatives. Here, $Z_B$ and $Z_K$ represent the performance parameters, whereas n represents the number of repetitions performed in an experimental combination and $Y_i$ i represents the performance value of the experiment.

The experiment that corresponds to the optimum working conditions in the Taguchi method may not have been performed during the study. For similar cases, the following additive model can be used in order to estimate the performance value for the optimum conditions (Phadke 1983):

$$Y_i = \mu + X_i + e_i \quad (3)$$

Here, m refers to the general average of the performance parameter, $X_i$ to the constant effect of the parameter-level combination, and $e_i$ to the random error. Since the equation is an estimated point computed using the experimental data, the confidence interval must be calculated to determine if this value is significant. The confidence interval at a given error level can be calculated by making use of the following equation (Ross 1989):

$$Y_i \pm \sqrt{F_{\alpha;1,DF_{MSe}} \times MSe \times \left(\frac{1+m}{N} + \frac{1}{n_r}\right)} \tag{4}$$

Here, F refers to the Chart value, α represents the error level, $DF_{MSe}$ to the mean square error total degrees of freedom, m to the sum of degrees of freedom of parameters used in the estimation of optimum operating conditions, N to the total number of experiments, and $n_i$ to the number of repetitions in the verification experiment. Provided that the experimental results are presented in percentage (%), before calculating the equations (3) and (4), the percentage values should be converted to omega values using the equation shown below. Then, the values of interest can be determined by inverse transformation by using the same equation (Taguchi 1987):

$$\Omega(db) = -10Log(\frac{1}{P} - 1) \tag{5}$$

Here, W (db) represents the decibel value found by the omega conversion of the percentage value and p shows the percentage value of the product obtained experimentally.

### 2.2. Calculation of Droplet Diameter

Each of the WSP samples collected after the spray application was scanned at 600 dpi resolution (Marcal & Cunha 2008) as an image file (.jpg), which was then transferred to a computer. Depending on the area of the stains on the card surfaces, the characteristic droplet diameter was determined by the image processing method and ImageJ (version 1.38x, Wayne Rasband, National Institutes of Health, US) software was used in the analyses. The average grayness values (g) of WSP images were measured and the threshold levels were determined by using the equation t= 0.38g + 78.75 (Sanches-Hermosilla & Medina, 2004). The stain images on the card surface were subjected to the shape analysis and a stain elimination process was performed using the method introduced by Sæbø and Wighus (2015). As a result of the analysis, depending on the stain areas, the diameter of stain (Ds, µm) was calculated by multiplying the determined equivalent diameter values by 42.3 [(25.4 / 600) × 1000] (Uremis et al., 2004). The diameter of spherical droplets (Dg, µm) was estimated by substituting the results in the equation $D_g = 1.033 \cdot D_s^{0.879}$ (Franz, 1993). An image file taken from the WSP surface for droplet sampling is demonstrated in Figure 3.

**Figure 3.** WSP image of spray application

To determine the characteristic droplet diameters, a macro program was prepared in MS Excel and an analysis was carried out in a range of 20 diameter classes (Srivastava et al., 1993). The definitions related with characteristic droplet diameters and the formulas used (Nuyttens et al., 2007) are given in Table 3.

**Table 3.** Equations for characteristic droplet diameter

| Arithmetic avg. diameter | Surface avg. diameter | Volumetric avg. diameter | Sauter diameter | Homogeneity |
|---|---|---|---|---|
| $D_{10} = \sum_{i=0}^{n} d_i/n$ | $D_{20} = \left(\sum_{i=0}^{n} d_i^2/n\right)^{1/2}$ | $D_{30} = \left(\sum_{i=0}^{n} d_i^3/n\right)^{1/3}$ | $D_{32} = \sum_{i=0}^{n} d_i^3 \Big/ \sum_{i=0}^{n} d_i^2$ | $r_1 = (D_{V0.9} - D_{V0.1})/D_{V0.5}$<br>$r_2 = D_{V0.5}/D_{N0.5}$ |

The definitions of the terms used in the equations are presented below.

$D_{10}$, $D_{20}$, and $D_{30}$ refer to the arithmetic, surface, and volumetric mean diameters, µm (i: class number, di to average droplet diameter in $i^{th}$ class, n to total number of droplets), $D_{32}$ to the diameter value with the same volume/surface area as the ratio of the total volume of all droplets to their total surface area (Sauter mean diameter, µm), $D_{N0.5}$ to the diameter value dividing the total number of droplets into two equal parts, (numerical median diameter, µm), and $D_{V0.5}$ to the diameter value in the volumetric distribution dividing the total droplet volume into two equal parts (volumetric median diameter, µm).

$D_{V0.1}$ and $D_{V0.9}$ refer to the diameter values corresponding to 10% and 90%, respectively, of the total droplet volume in volumetric distribution, whereas µm $V_{100}$ and $V_{200}$ refer to the percentage of droplets having a diameter of <100 and <200 µm, respectively, in volumetric distribution, %

r1 represents the droplet homogeneity, dimensionless

r2 represents the droplet homogeneity coefficient, dimensionless

$D_{min}$ - the smallest measured diameter value, µm

$D_{max}$ - the largest measured diameter value, µm

## 3. Results and Discussion

The data obtained from the experiments and measurements were analyzed using the ANOVA-TM package program in order to determine the effect of each parameter on the performance statistics. The effect of each parameter on the optimization criteria was calculated separately and the results are shown in Figure 4.

The numerical value of the maximum point in the graphs shows the best value for the given parameter, whereas the numerical value of the minimum point shows the worst value. In the graph illustrating the effect of droplet diameter (Figure 4), the minimum points of all parameters show the optimum levels of that parameter in the given level range selected in the experimental study.

At this point, it may seem difficult and complicated to understand the experimental results using the graphs given in the figures. For example, Figure 4 shows the change of the "performance parameter A" with spraying pressure. At the first point, the spraying pressure is 6 bar and it corresponds to the first level of this parameter (see Table 1). The experiments corresponding to Level 1 are included in the A column in Table 2 and the corresponding experiment numbers are 1, 2, and 3. Performance value is the average of the data obtained from these experiments. The experimental conditions for the 2$^{nd}$ data point in A in Figure 4 are the average of the experiments shown with 2 in column A (i.e.; 4, 5, and 6).

The numerical value of the minimum point in each graph indicates the best value of the given parameter. These values are given for each parameter in Table 4 and they express the optimum value of each parameter under the experimental conditions.

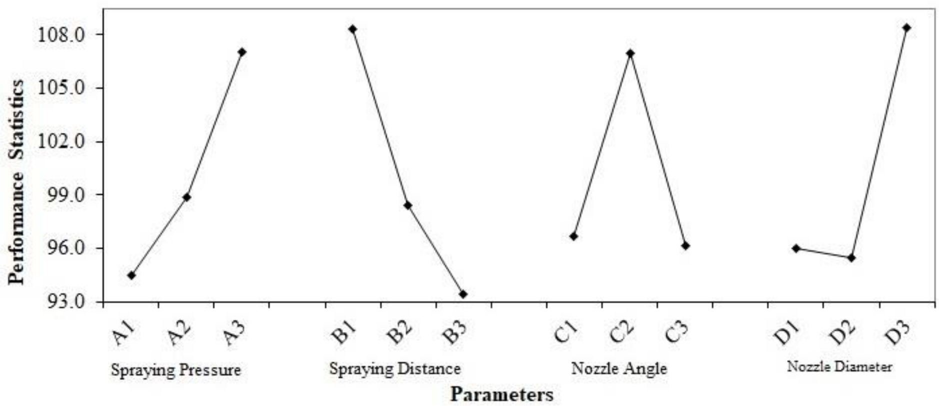


**Figure 4.** The effects of the parameters on the droplet diameter

Furthermore, the performance values of combinations corresponding to the optimum conditions estimated using the equations 3 in Table 4 and the confidence interval at 5% error level for these predictions were calculated with the help of equation 4, both of which are provided in Table 4. To test the accuracy of these estimations, verification tests were conducted under the optimum conditions and the results are given in the "Real" line. Since the performance values obtained in the validation experiments are within the calculated confidence interval, it can be stated that the experimental results are acceptable at the 5% error level.

**Table 4.** Optimum design parameters

| | | Parameters | | | | Performance Values | | |
|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | Volumetric Median Diameter | | |
| | | P | H | α | d | Conf. Inter. | Real | Est. |
| General | Optimum Level | 1* | 3● | 3° | 2+ | 79.833 - 100.111 | 93 | 91.6 |
| | Optimum Value | 6 | 100 | 30 | 1.10 | | | |

•:Effective 1st deg. +: Effective 2nd deg. *: Effective 3rd deg. o: Effective 4th deg.

In Figure 5, the contribution percentages of the parameters to the selected performance characteristic can be seen. The contribution percentage shows the effect of the given parameter on the performance statistics and each one of them was calculated using the formula below.

$$CP = \frac{Square\ Sums-(Degree\ of\ Freedom\ x\ Error\ Sum)}{Square\ Sums} \quad (6)$$

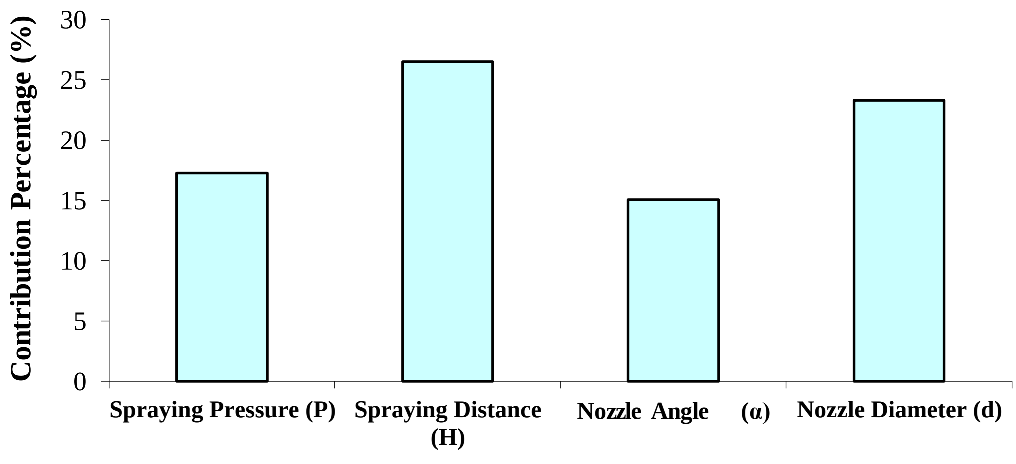


**Figure 5.** Contribution Percentages of the Parameters on the Volumetric Median Diameter

The effects of the parameters on the Volumetric Median Diameter (VMD) are the spray height (H), the nozzle orifice diameter (d), the spray pressure (P), and the nozzle angle (α), respectively. The most effective parameter on the volumetric median diameter is the spray height. The increase and decrease of the spray pressure, nozzle diameter, and mean angle that the maximum distance that the droplets can reach are affected. The droplet density and diameter increase with a decrease of the spray height. In this study, the spray height set at 100 cm yielded the smallest Volumetric Median Diameter. The second parameter influencing the Volumetric Median Diameter was the nozzle diameter (d). In this study, the nozzle diameter set to be 1.10 mm yielded the smallest VMD. The third parameter that influenced the VMD was the spray pressure (P). The spray pressure is one of the parameters decreasing the droplet diameter in spray application. The spray pressure affects the maximum distance that the droplet can reach, as well as the droplet diameter. In literature, it was reported that the droplet diameter values increased as the spray pressure value decreased. From this point of view, it can be seen that our system supports the literature. In this study, the spray pressure set at 6 bar yielded the smallest VMD. The fourth parameter that influenced the VMD is the spraying angle (α). The increase in the spraying angle affects the maximum distance the droplet can reach, depending on the operational pressure and the nozzle orifice diameter. Moreover, the nozzle angle of 30° resulted in the smallest VMD.

## 4. Conclusions and Recommendations

In this study, it was aimed to reduce chemical use and protect the environment by optimizing the parameters affecting the droplet diameter. The effects of flow conditions on the droplet diameter were investigated using the Taguchi experimental design method in the spraying experimental setup created using water-sensitive papers. Mean Median Diameter was chosen as the performance characteristic. Examining the optimum conditions for the performance characteristics, where optimal results were calculated by processing the images obtained from water-sensitive papers and calculating the Average Median Diameter, the optimum values achieved were 6 bar of spraying pressure, 100 mm of spray height, 30° of nozzle angle, and 1.1 mm of nozzle orifice diameter. The parameters influencing the Volumetric Median Diameter were found to be spraying distance (H), nozzle diameter (d), spraying pressure (P), and nozzle angle (α). Using the Taguchi method, the optimum conditions can be determined by considering the effects of all parameters together. Verification tests were carried out under optimum conditions, and it was concluded that the results were compatible with the analysis. In the future, pesticide application may depend on external factors (wind speed, humidity, temperature, etc.), the number of parameters can be increased and optimum conditions and interaction between parameters can be investigated in more detail. In particular, studies aimed at determining flow characteristics are complex studies. Therefore, in addition to the droplet diameter and homogeneity values obtained in this study, the adhesion amount of the substance can be calculated by using the droplet density and trace material. In this way, more detailed information can be obtained about pesticide efficiency. Flow phenomena can be solved numerically using different flow simulation methods and CFD software such as Fluent and Comsol.

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**Authors' Contributions**

All authors contributed equally to the study.

**Statement of Conflicts of Interest**

There is no conflict of interest between the authors.

**Statement of Research and Publication Ethics**

The author declares that this study complies with Research and Publication Ethics.

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