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Assessment of spray characteristics by studying the effect of nozzle sizes, air-assisted speed and their interaction

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Abstract

The efficiency of spray applications in agricultural fields is directly affected by nozzle characteristics and sprayer operating parameters. This work investigates the optimization of a comment spray nozzle characteristics in laboratory conditions by testing the effect of different nozzle sizes and air-assisted speeds on the spray pattern including spray width, spray angle, and accumulated amount of spray deposited on the target zone. Four flat fan nozzle sizes (0.3, 0.5, 0.6, and 0.8) and three air-assisted speeds (3.5, 6.5, and 9.5 m s^{-1}) were used. All measurements were performed at the working pressure of 2 bar and a spraying height of 25 cm. Collected data were analyzed using factorial experiments using a completely randomized block design. To test the significance differences between the treatments studied, the least significant difference (L.S.D.) test at the 0.01 probability level was used. Preliminary results showed a significant difference of nozzle size, air-assisted speed, and their interactions on spray characteristics. A larger flat fan nozzle size (0.8) generally produces wider spray patterns. Whereas, the air-assisted speed increases by 9.5 m.s^{-1} enhances the dispersion of spray droplets, resulting in wider coverage, affected by the result of accumulated spraying, and reducing the deposition efficiency on the grooves of the accumulated liquid collection device. However, the optimal spray width (0.65m) and spray angle (52°) for maximum spray volume (1.6 L.min^{-1}) are achieved when these factors are carefully balanced at nozzle size (0.6) and air assistance speed (6.5 m.s^{-1}). The results of this study provide a comprehensive analysis of how varying these factors affect the spray features and provide practical guidance for optimizing spray characteristics to achieve desired results in different spray applications. The results underscore the importance of selecting nozzle size and air-assisted speed settings for the specific operating conditions to enhance spray effectiveness and efficiency.

Keywords: flat fan nozzle, spray width, spray angle, accumulated spray deposition, patternator device

Introduction

Controlling of agricultural pest is considered as one of the most prominent challenges in the modern agriculture, in order to protect the cultivated crops from insects, fungi, weeds, and microorganisms, which cause major economic losses then effect on the food security. One of the most widely used techniques in agricultural fields is a chemical control utilizing pesticides (1). The process of pesticide spraying requires the effective use of different types of insecticides, fungicides, and fertilizers to achieve the best desired outcomes, as sprayers are used in the farms for improving the crop yield and quality (2). During the spraying application, it is preferable to reduce the amount of spray drift and amelioration the amount of spray deposited on the leaves. these losses are varied depending on the different factors as farmers skills during spraying processes (3). Using of agricultural sprayer is to distribute the pesticides effectively, reduce pollution as possible, and increase the efficiency of deposition on the plant canopy, which considers as an essential issue in agricultural spraying techniques. (4) The traditional sprayers included various advantages as their availability in the local markets, low cost and easy to maintenance. However, they depend in field operating on the their stressful when carried on the worker back and operator skill, which may be led to increased drift results. (5) Therefore, many attempts have been carried

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out to improve their efficiency, it includes applying global protocols to reduce losses during the spraying application. The drift reduction techniques (DRTs) are critical to evaluate possibilities for improving distribution and enhancing spray sedimentation. Some of studies have shown that the air-assisted speed with knapsack sprayers might enhances spray deposition and penetration, especially in the cultivated crops with high leaves density (6). The study also illustrated the effect of air speed on the effectiveness of spraying characteristics and improving the efficiency (7).

For the spray coverage, significant affect depending on plant canopies; dense canopies show much lower levels of penetration, resulting in many pests remaining in non-penetrated areas (8). Hence, it is recommended to adopt an advanced spraying techniques as pneumatic sprayers to improve the spray distribution and achieve a better balance of pest control (9), which means using smaller amounts of it to achieve the same effectiveness, thus reducing cost and reducing environmental impact (10). The spray coverage on the intended surfaces of leaves showed that the increasing of air-assisted speed inside the plant canopy led to improved coverage of the lateral deposits in both of pear and cherry plants leaves (11). Furthermore, a study showed that using air to push spray onto the leaves of pepper plants in greenhouses increased the deposition rate on the upper and lower parts of the plants by 63% and 52%, respectively, achieving a significant increase in the amount of solution deposited (12). Selecting the appropriate nozzle and characteristics is also one of the basic factors that greatly affect the effectiveness and efficiency of the spraying process, as it plays an essential role in the transformation of spray solution to small droplets that are distributed on the plant surface, as this varies according to the type of nozzle and its sizes. The amount of solution applied per unit area is also determined by the operating pressure and nozzle characteristics during spraying (13). A study indicated the importance of testing nozzles periodically to ensure proper performance, as outdated nozzles might led to unexpected findings. The results showed that spray pressure between 3.0 and 7.0 bar led to different flowrates (1.314, 1.286, and 1.36 $L.min^{-1}$). The nozzle type also had a significant effect on flow rates, while spray pressure significantly affected angle, with angles increasing from 132 to 136 degrees as pressure increased. The consumer nozzles produced higher spray angles compared to the modern nozzles. On the other hand, higher spray pressure increased the spray area, and expendable nozzles also contributed to expanding sprayed areas (14). The airflow angle also has a significant influence on the spray deposition of the treated surfaces, with optimal angles leading to improved deposition efficiency (15). Due to the frequent incorrect use of the spraying process, which is not balanced on the intended target by the farmers, and insufficient studies that dealt with the regularity of the spray deposition on the leaves density, and the difficulty of choosing the optimal balance between the nozzle sizes, air speeds, operating pressure, and spraying height to improve the spraying characteristics at a better spraying angle and width. So, the current investigation aims to study the optimal spray width and angle for increasing the amount of spray deposition on the intended target zone with the least losses by studying the effect of both flat fan nozzle sizes and air-assisted speeds and their interactions using the electric knapsack sprayer.

1. Materials and Methods

This study was performed in the laboratory of plant protection equipment in the department of agricultural machines and equipment at the college of Agriculture, University of Basrah, using an electric backpack sprayer (16l) total tank capacity under different operating conditions. Flat fan nozzles in different sizes (0.3, 0.5, 0.6, and 0.8) and three air speeds (3.5, 6.5, and 9.5 m) supported from rechargeable air blower were used.

1.1. Measurement of the actual flowrate amount

Nozzle flowrate was measured in laboratory conditions based on calibration the spray nozzle under a constant operating pressure (2) bar and at a constant height (25)cm by spraying in graduated cylinders and for a specified exposure spraying time. The pure water was used in all spraying process. The nozzle disposed amount was summed up to calculate the actual flowrate in the fixed time. The experiments were repeated three times for each nozzle size, then average was separately calculated according to the :following formula was used to

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$Q = \frac{Vi}{t} * f$ ………………….. (1)

where:
Nozzle flowrate ($lmin^{-1}$) Q:

Exposure time (sec); f :Constant factor Vi: The collected amount in the graduated cylinder (ml); t : (0.06)

2.2. measurement of the spraying width

The actual spraying width was measured using the Patternator device as shown in Figure (1). This device is designed with dimensions of (2.4*0.3 m) length and height respectively. The device contains 49 grooves at (0.05m) spacing between two grooves adjacent. A graduated cylinder (total capacity 50 ml) was installed at the end of each groove to collect the accumulated amount of water separately. The nozzle orifice was fixed at a height of (0.25 m), which is the distance between the nozzle orifice and the horizontal surface of the patternator. The practical's spray width was calculated using the following :formula

$W = C \times n$ …………………(2)

where:

Number of grooves containing water (m); N: (0.05) Single groove width C: W: Spray width (m); after spraying process.

2.3. Measurement the spraying angle

The spraying angle was experimentally determined based on the spraying width and height, as shown in Figure (1). According to the following formula, after finshing the nozzle flowrate measuement control at a specified air speed.

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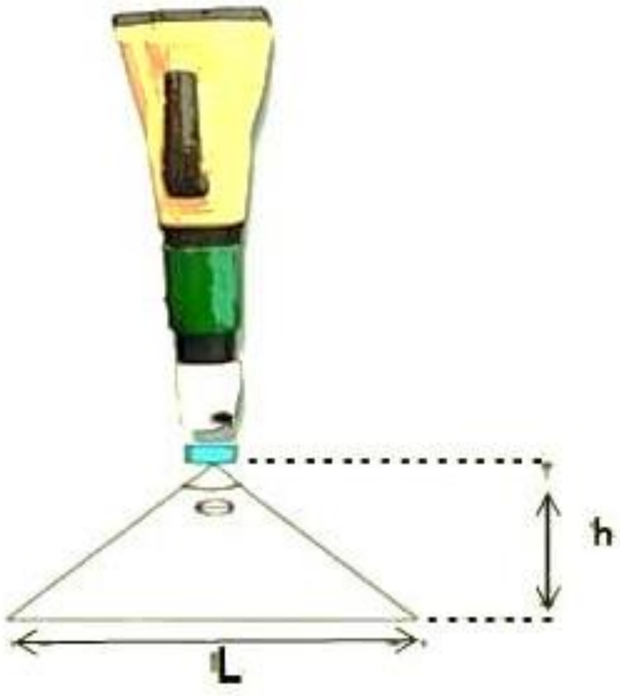

Figure (1) Mechanism used for measuring spray angle

(3)..................$\theta = \tan^{-1}\left(\frac{L}{h/2}\right)$

where:
(m) L: Actual spray width (m); h : spray height ; (°) : Spray angle θ

2.4. Spraying mechanism and experiment supplies:

As shown in Figure (2), the components and spraying mechanism that used in this experiment. It includes a Patternator device to measure the spray width and uniformity of spray distribution during the spraying process, an electric backpack sprayer with a tank capacity of 16 liters that supported with a pressure gauge. A chargeable air blower was used as capable for generating the air speed at different levels and can be controlled. In addition to graduated cylinders was supplied for sedimentation measurements to calculate the accumulated amount. It was also used Anemometer model BM 6253 during the experiment, for recording the weather conditions. Moreover, a special iron structure is designed to hold the air blower and nozzle, which contributes to integrating the air-assisted nozzle action effectively.

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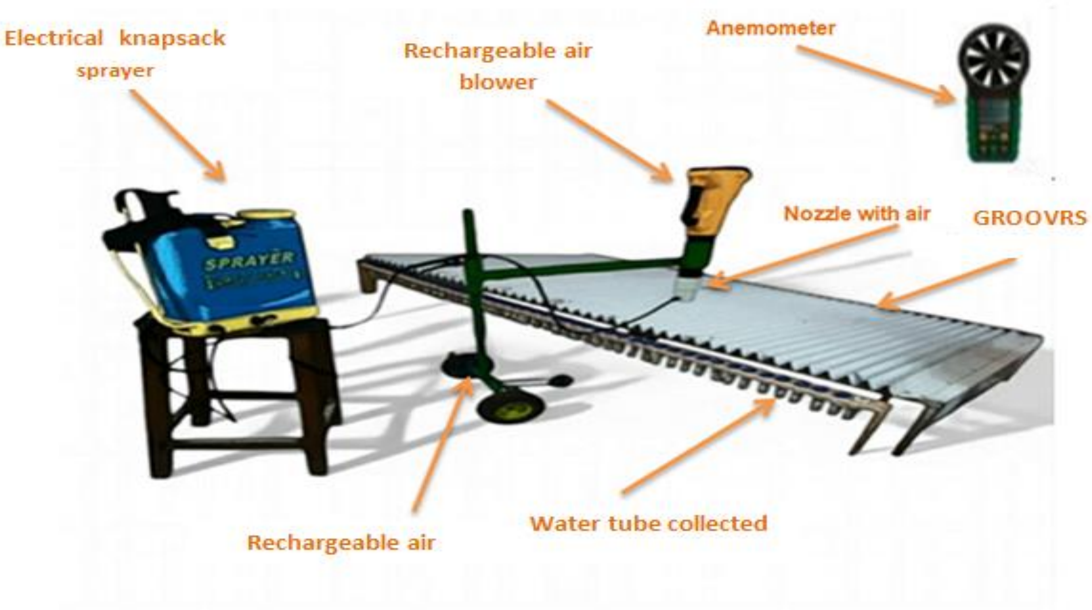

Figure (2): Requirements of spraying process

2.5. Statistical analysis

The results were analyzed using the method of factorial experiments using a completely randomized block design, and the means were compared using the least significant difference test (L.S.D.) at the probability level of 0.01 to test the significance of the results using the statistical analysis program Genstat

3. Results and discussion

3.1. Effect of nozzle size on the nozzle flowrate:

The results of the statistical analysis of the F test showed that the size of the nozzles has a significant effect on the discharge rate, as shown in Figure (3). The nozzle with a volume of 0.8 recorded the highest average value of (1.58 litres.min^{-1}), while the spray nozzle with a volume of 0.3 recorded the lowest average value of (0.86 litres.min^{-1}). The discharge rate increases as the nozzle size increases. Therefore, the significant increase in the nozzle size increased with the increase in the size of the nozzles to the point where the nozzle size was equivalent to the spray height of 25 cm and the operating pressure (2 bar). Then the spray efficiency decreased with the increase in discharge, as it recorded a volume of 0.5 and 0.6 balanced discharge rate of respectively (1.16, 1.49) litres.min^{-1}, while it increased at the nozzle size to 0.8 due to the nozzle size not being proportional to the spray height and pressure. The reason may be attributed to the amount of pressure being positively proportional to the nozzle size. When the pressure increases The discharge increases, and thus leads to an increase in loss and erosion, as shown (16).

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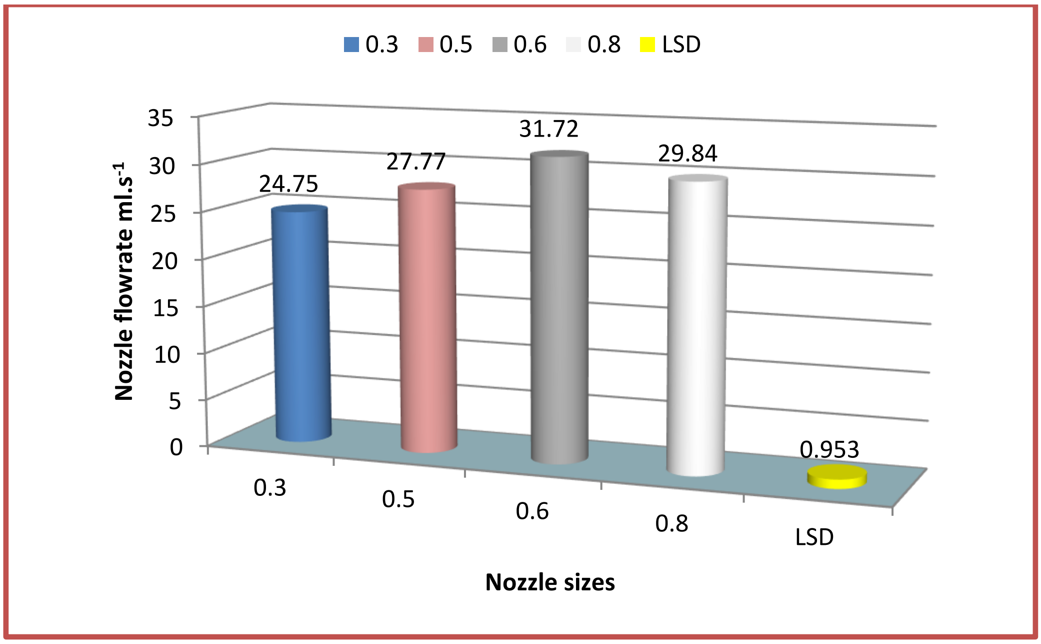

Figure (3): Nozzle flowrate based on nozzle sizes

3.2. Effect of air speed on accumulated spray nozzle:

Figure (4) shows the results of the statistical analysis of the F test. The air speed is 9.5 m. Second-1 recorded the highest average of (1.44 litres.minute^{-1}). While the case of not using air speed (0) recorded the lowest average of (1.09 litres.minute^{-1}). The results showed that increasing the air speed leads to an increase in discharge, and this increase leads to improving the spray characteristics to a certain extent, as recorded by the air speed of 6.5 m.s-1 with an average of (1.3 l.min^{-1}), then the high increase in air speed causes spray drift. And loss, so choosing the appropriate air speed gives balance to the spraying process and increases efficiency by increasing the amount deposited and decreasing loss and drift, and this is consistent with (17).

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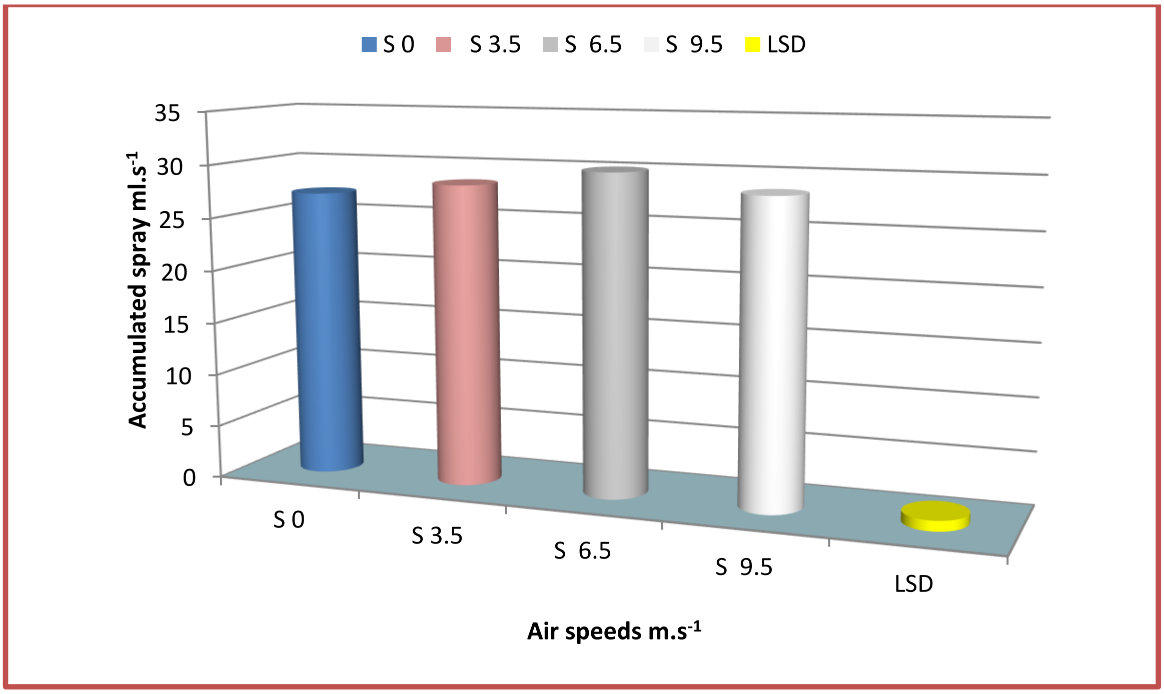

Figure (4): A cumulated spray on patternator with air-assisted speed . The symbol (Si) is represented air-assisted speed

3.3. Interaction between nozzle size and air-assisted speed:

The results of the statistical analysis of the F test showed that there were statistically significant differences in the interaction between the size of the nozzles and the types of air speeds, as shown in Figure No. (5), where the interaction was significant between the nozzle size of 0.6 and the air speed of 6.5 m. second-1, as it gave an arithmetic average of (1.6) litres.minute-1, while when the nozzle size was increased by 0.8 at the same speed, a greater average was recorded of (1.7) litres.minute-1. This leads to an increase in liquid consumption, and when the speed is increased Air 9.5 m/s-1 The discharge rate decreased for both nozzles, as the nozzle recorded an average volume of (1.4) liters. min-1, and the nozzle with a volume of 0.8 had an average of (1.6) litres. min-1. This decrease was attributed to the high air speed that led to spray drift, while the interaction between the nozzle with a volume of 0.3 and no air speed recorded a lower arithmetic average of (0.69) litres. min -1. This indicates that the 0.6 nozzle achieved a consistent spray with constant dispersion at an air speed of 6.5 m. Second - 1, and the reason for this is attributed to the air speed balanced with the size of the droplets, which improves the spray coverage and increases the ability of the pesticide to penetrate and reach the target, as shown (18).

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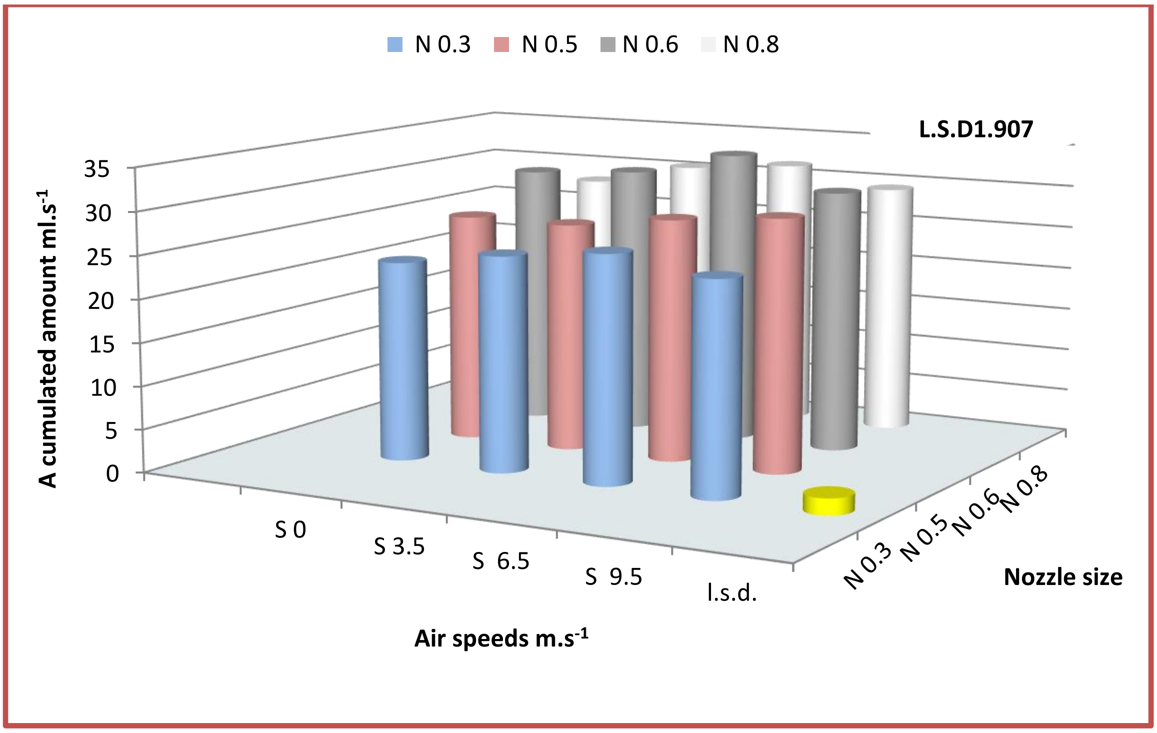

Figure (5): A cumulated spray interaction according to nozzle size and air speed. The symbol (N) is represented the nozzle size and the symbol (S) represented the air speeds

The results in Figure (6) showed the distribution of spray on the grooves using the formula (4). The variation in values were observed in the accumulated quantities after using air speeds, and there is a clear relationship between the nozzle size, air speed, and spary amounts. The highest accumulated spray value of (2. 1 L.min $^{-1}$) was recorded at the nozzle size (0.8) with air-assisted speed of (9.5 m.s^{-1}), while the L.min $^{-1}$). The nozzle size (0.6) and air speed (9.5 m.s^{-}5same nozzle size without air speed recorded (1. ^{1}) recorded the largest accumulated amount (1.7 L.min $^{-1}$). The nozzle size of (0.6) appeared a medium spray amounts ranging between (1.3-17 L.min $^{-1}$), and it also showed a spray amount of (1.6 L.min $^{-1}$) at high speed of (6.5 m.s^{-1}), which appeared the balance in results. (Volume accumulated with air speed) enhances a positive balance with the amount of spray compared to the other nozzle size.

The other two nozzle sizes (0.3 and 0.5) recorded the largest accumulated amount (1.5, 1.2 L.min $^{-1}$) at air speed of (9.5 ms^{-1}) and without air speed (0.8, 0.72 L.min $^{-1}$) respectively. It turns out that the greater nozzle size or the air speed, the greater the amount of spray collected. The reason is attributed to forcing and emerging the liquid particles confined to the middle and edges, which leads to a faster and sharper flow. This outcome is agreed with the results of (19).

Discharge amount (L.min $^{-1}$)= Quantity collected/ Exposure time×0.06…………(4)

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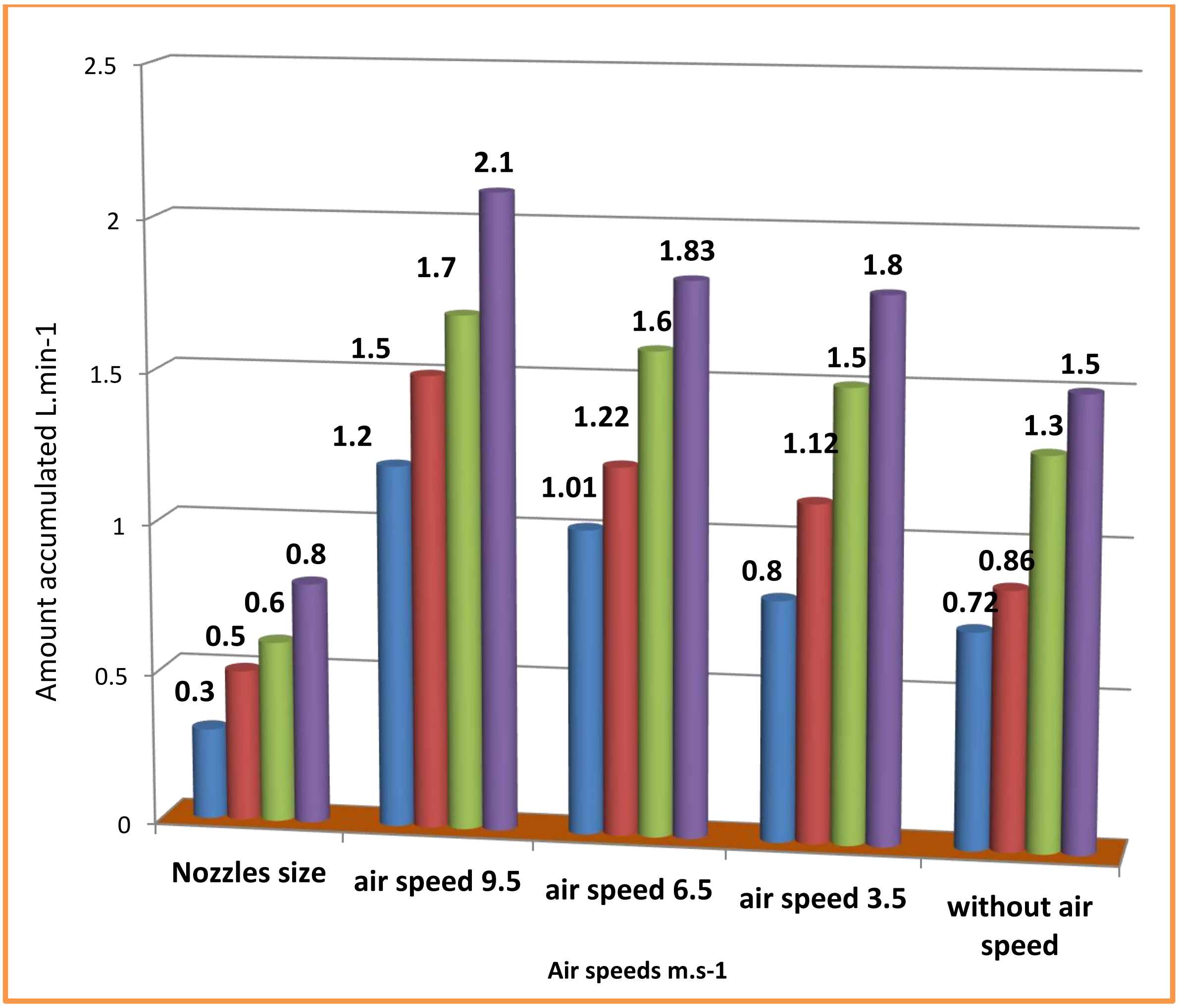

Figure (6): A cumulated spray amount based on air speed

3.4. Effect of nozzle sizes on spraygin width:

Figure (7) showed that the spraying width significantly influences with nozzle sizes. It decreased with the increase of nozzle size. Also, the choosing of the appropriate nozzle size helped to obtain a suitable spraying width for the treated area, which led to more spray deposition with a decrease in the amount of losses. This finding is agreed with (20).

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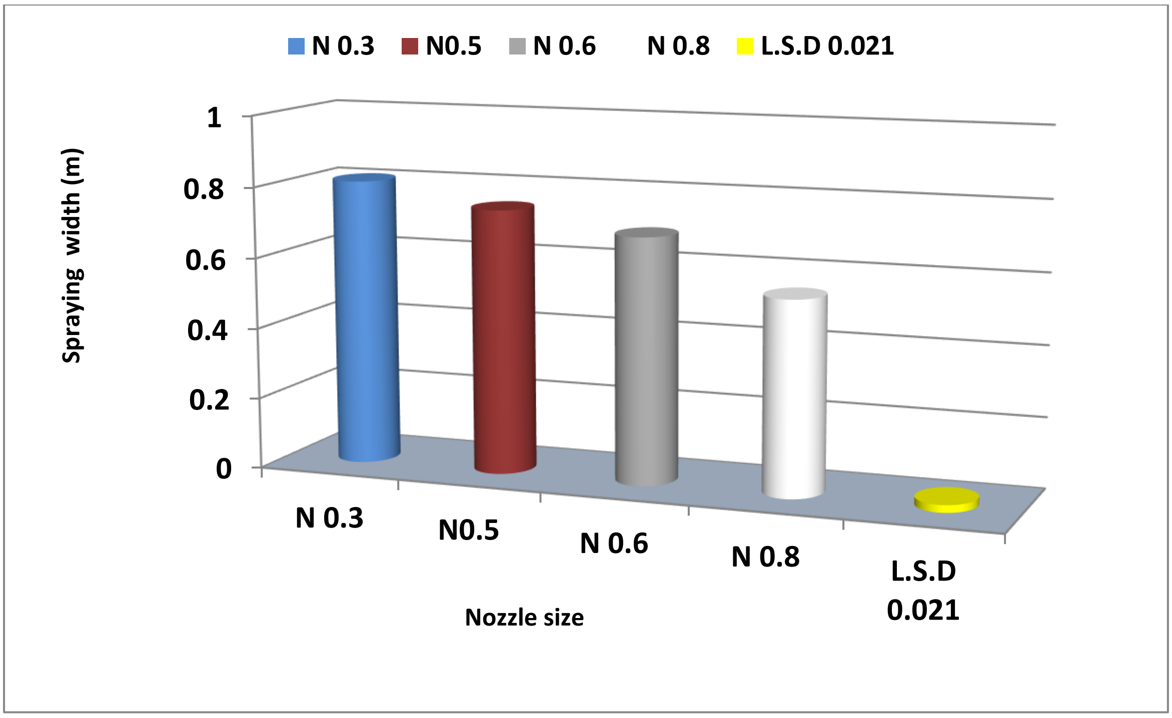

Figure (7) shows the effect of nozzle size on spray width. The symbol (N) represents the size of the nozzles

The nozzle size (0.6) recorded an average spraying width of (0.692 m), and this was in proportion to most average width of the corn crop canopy. A corn plant cultivated in a pot was measured in the laboratory and the field after 50 days of seeding, ranging width from 60-70 cm (Figure 8), which is Mostly, the infestation of a common agricultural pests begins at a height ranging between (80-100 cm), while the nozzle size (0.8) recorded a decreasing with an average spraying width of (0.546 m). In contrast, the spraying width increased at the nozzle size of (0.5) with an average value of (0.746 m), and the nozzle size of (0.3) with an average of (0.808 m). The reason may be attributed to a change in the spray width as a result of the nozzle size, which led to the appearance of droplets at certain sizes depending on the nozzle size, and as a result of the force of operating pressure and the spraying height. This causes a change in the spraying width. This outcome is agreed with (21)[2], (22).

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Figure (8): Measuring of plant width and height in the field and the laboratory conditions

3.5. Effect of air-assisted speed on spraying width

Air-assisted speed significantly affected on the results of spraying width. as it turns out that increasing of air-assisted speed led to a decreasing in spraying width. However, a slight increase in spray width could occur as the speed continues to augment. As shown in Figure (9), the case of no air-assisted speed was recorded with an average spraying width of (0.77 m). While the air speed estimated at (3.5 $m.s^{-1}$), the spray width decreased to an average of (0.70 m), and this decrease continued when the air speed increased to (6.5 $m.s^{-1}$), where the average spray width reached to (0.63 m). However, the air speed of exceed to (9.5 $m.s^{-1}$), a slight increasing in the average spraying width was observed to overwhelmed up to (0.78) m.

The results also indicated that the appropriate air-assisted speed positively effects on the efficiency of the spraying process, as it contributes to reducing the spray width in proportion to the treated area, which led to reduce the losses and improving the spray deposition amount on the specific target. However, the increasing air speed to high levels may be led to negative results, which necessitates to select the appropriate speed with care and balance of spray deposition. This finding is agreed with the results of (23).

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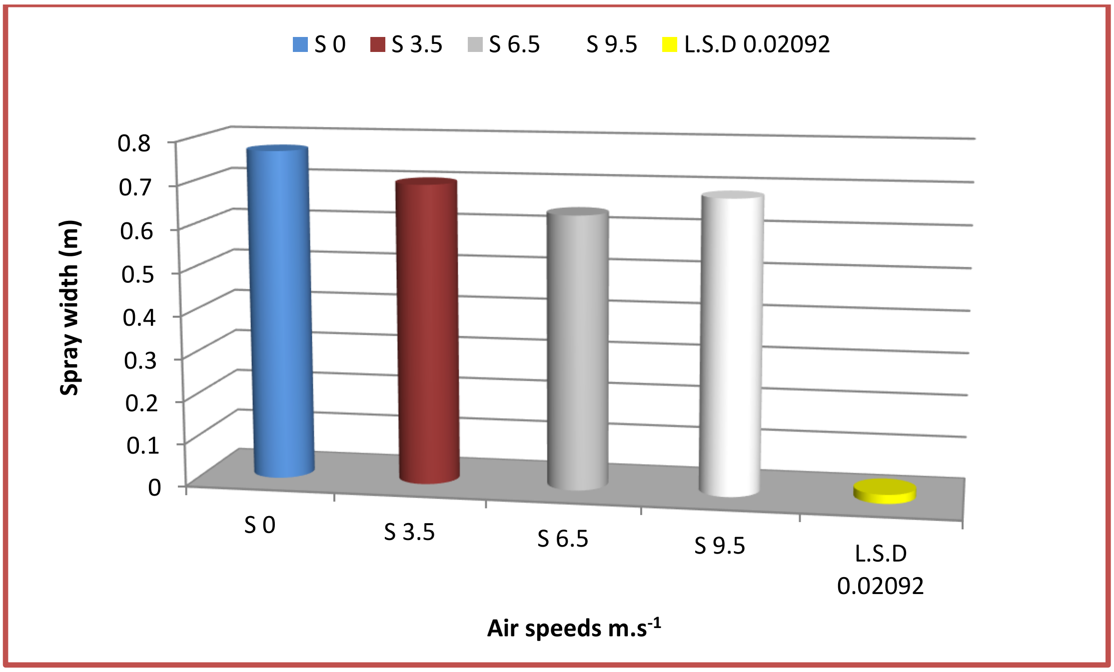

Figure (9): Spray width results based on air-assisted speed affect. The symbol (s) represented air speed

. The interaction values between nozzle sizes and air speed on the spraying width63.

The results of statistical analysis (F test) showed that there are significant differences in the interaction between nozzle sizes and air-assisted speed on spraying width. As shown in Figure (10), It required that the spray width be in a balance with the target. When the spray width increases or decreases beyond the required limit, it appeared undesired results. The outcomes showed that the nozzle size (0.3) recorded the highest average spraying width when there was no air-assisted speed (0.93 m). However, the increasing in nozzle size and the air speeds, the values gradually decreased until it reached (0.43m) especially at a nozzle size of (0.8) and an air speed of (9.5 m.s^{-1}).

The nozzle size of 0.5 gave the largest average among the nozzles when there was no wind speed, reaching (0.78) m, then it decreased when the air speed increased by 9.5 m.s^{-1}, reaching an average of (0.63) m, and the high air speed led to 9. m.s^{-1} to strong bending of the plant's leaves and thinner stems.

While the nozzle size (0.6) recorded at air speed of (6.5 m.s^{-1}) spray width (0.65 m). It was also observed when the spraying process carried out at this air speed, it affected on the plant leaves with a vibrating movement, especially at the lateral edges of the plant leaves, which led to their a slight movement and vibration estimated at 2-4 cm within the area of the spraying width (Figure11). These phenomena reflected more spray deposition of liquid during the spraying process, which led to an optimal balance with the average of plant width (plant in the pot), with an average of (60-70cm) (Figure 8). The balancing between air speed and nozzle size achieved an uniform spray coverage, which reduced untreated areas especially with higher spray efficiency (Y et al., 2020). The interaction between the nozzle size (0.6) and the air speed (6.5 m.s^{-1}) produced a very balanced and acceptable spraying width. The main reason for this may be due to the uniformity of droplets size, their distribution, and their balanced consistency at the air speed. This result is agreed with (24), (25).

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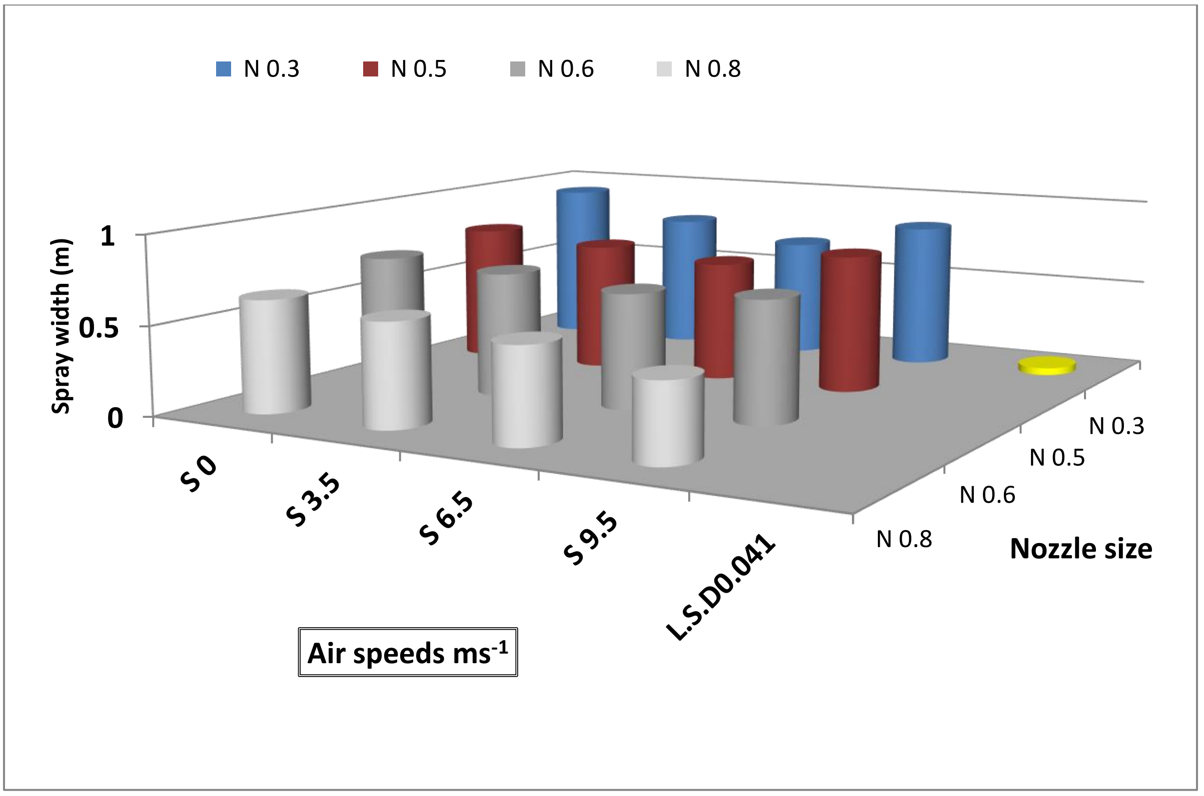

Figure (10): Spray width values based on the interaction between nozzle size and air speed. The symbol (N) represented the nozzle sizes ; (S) represented the air speeds.

Figure (11): The vibration of plant leaves as a result of air-assisted speeds

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3.7. Effect of nozzle sizes on spraying angle:

As shown in Figure (12) the effect of nozzle sizes on the spraying angle, explaining the relationship between different values of nozzle size and their effect on the spray angle. It appeared that the spray angle decreased with increasing the nozzle sizes. Selecting the appropriate nozzle size has a significant influence on the spray efficiency. The values of spray angles indicated that the nozzle size (0.3) recorded the highest spraying angle value (57.99°) compared to other nozzle sizes. The nozzle size (0.5) illustrated spraying angle of (56°). The largest nozzle size of (0.8) recorded the lowest angle value (47°), while the nozzle (0.6) showed average values at an angle of (54°), which indicated that increasing in the nozzle size may be led to a decrease in spray angle due to the increasing in the droplet sizes. Then led to a decrease in the spraying width, and the excessive increase in the spray angle at smaller nozzle sizes led to a wider and inappropriate spray coverage, causing more losses as a particle droplets. Therefore, the nozzle size is considered one of the basic elements that affect the performance of the spray system based on the droplets size, which is affected by the spraying angle. When the spray angle decreases, it leads to an increase in the thickness of the membranes of the liquid particles, as it is related to the droplets size. Higher spraying angle, more a smaller the droplets size, wider spray angle, which cause an increase in the treated of spray area. It may be led to inappropriate spraying effectiveness. On the other hand, spraying angles of appropriate value focus the spraying process on specific areas, which enhances the accuracy of spray distribution and the effectiveness of spraying in pest control. It also affects the penetration of the pesticide into the lower parts of the plant, which is extremely important. So, the choosing of the appropriate nozzle size has a significant influence on the spraying efficiency (26).

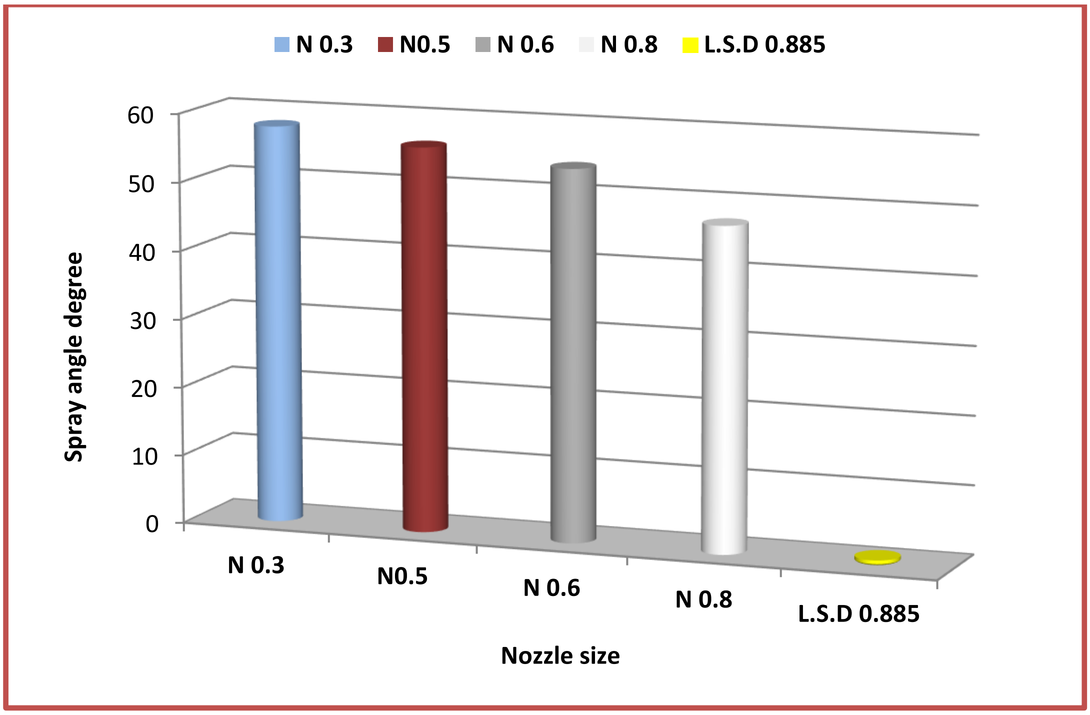

Figure (12): Actual spray angle according to nozzle size. The symbol (N) represented the size of the nozzles

3.8. Effect of air speed on spraying angle

Figure (13) showed the effect of air speed on the spray angle. It showed a decrease in the spray angle with increasing of air speeds. There are significant differences between the air speeds and their effect on

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the spray angle, it showed a clear decrease when the air speed increases to a certain value, then the value of the spray angle increases very slightly when the air speed increases as a result of the light spray droplets scattering aside, leading to a slight increase in the spray angle.

In the case of no air speed (control treatment), the highest average of spray angle recorded (56.61°), then it decreased with an air speed of (3.5 ms^{-1}) to record (54.05°), and it continues to decrease with an increase in air speed of (6.5 ms^{-1}) to achieve a spray angle (51°). Then after, the spray angle increases slightly at the speed of (9.5 ms^{-1}), recording an average angle of (52.75°).

The results reflect the positive effect of increasing of the air speed on the spraying angle to a certain range, then increasing the air speed led to negative results, which requires carefully choosing a balanced air speed for obtaining a positive balance in the spray angle, which leads to regular speed of the droplets trapped in the middle and the edges of the spray. The outside of nozzle to give a smooth flow of a good spray coverage, increase the amount that deposited, and reduce the losses. Based on these results, it can be inferred that choosing a balanced air speed is an influential factor in improving the spray angle. This finding is agreed with (27).

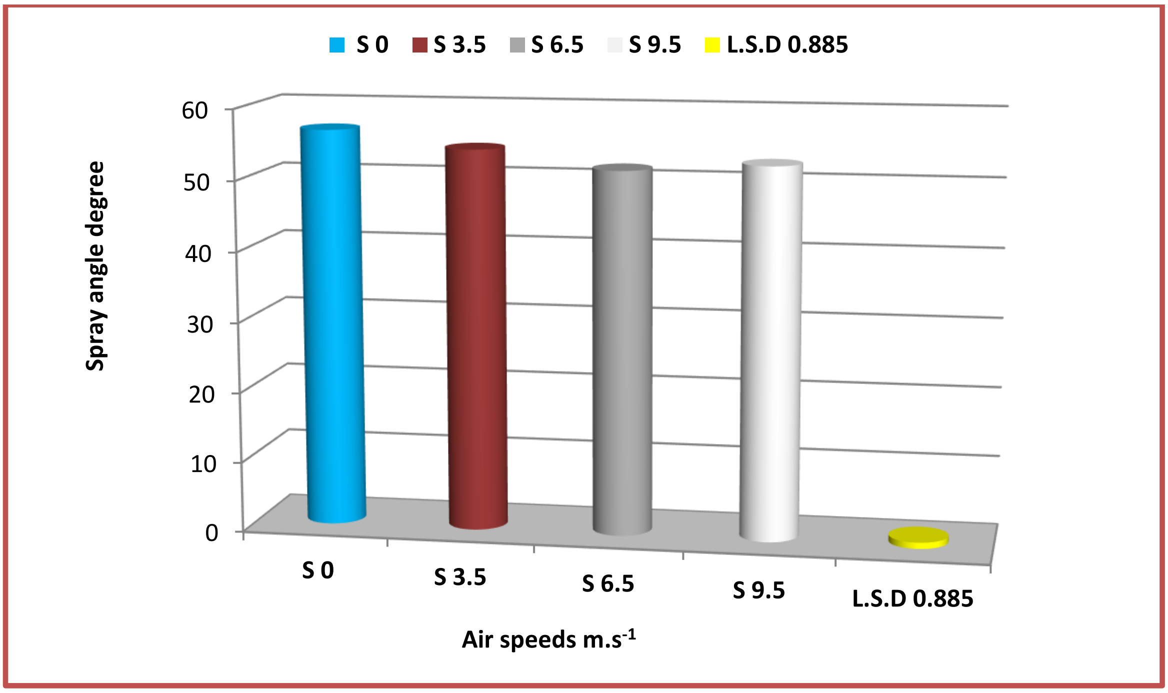

Figure (13): Values of spray angle based on air speed. The symbol (s) represented air speeds

3.9. Interaction of spray angle values between nozzle sizes and air

The results of the statistical analysis (F-test) showed that there were statistically significant differences in the interaction between nozzle sizes and air-assisted speeds. As shown in Figure (14), the results appeared that the nozzle size (0.3) recorded the highest spraying angle in comparison to the other nozzle sizes, especially at a low air speed, and increasing nozzle size (0.5, 0.6), which led to a gradually decreased in spraying angles. In the absence of air speed, the spray angles are generally higher, while the air speeds increase, a decrease in spray angles, especially with larger nozzle sizes. Therefore, smaller nozzle size (0.3) maintained the highest spray angles across all air speeds. The interaction between the (0.6) nozzle size and

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the air speed of (6.5 m.s^{-1}) recorded the spraying angle reached (52.43°), giving a spray width of (65 cm), which achieved a good proportion to the width of the plants, outperforming all interactions between nozzle size and air speeds. When the nozzle sizes and air speeds increase, the decrease in spraying angle increases. The nozzle size (0.8) recorded at the air speed of (9.5 m.s^{-1}), the lowest average value of spray angle (40.82°). Smaller nozzles appeared a greater spray angles, while increasing in the air speed led to reducing in the angles. These results show that the indicator with the greatest effect on the spray angle was the air speed, followed by nozzle size. This indicates is a proportionality between droplet size and air speeds, which contributed to achieve an appropriate spraying angle at the nozzle size of (0.6) and the air speed of (6.5 m.s^{-1}). It also produced an air speed increase of (9.5 m.s^{-1}). A narrow spray angle than the required limit, which led to ineffective dispersion of the spray and confining it to a smaller treated area. This reduce in the efficiency of spraying, and larger nozzles (0.8) produce a larger and a heavier droplets that make less dispersed, which led to focusing the spray on a specific area. Also, when the air speed increases, the small droplets from the smaller nozzles, especially at the nozzle size (0.3), are easily affected, which led to the spray angle being dispersed and unstable. The use of smaller nozzle sizes in constant conditions of a high air speed led to changing in the spray angle and is susceptible to losses. Therefore, the relationship between nozzle size and air speed determines the ability of the nozzle to produce droplets at a suitable conditions and give a better spray angle. So, it requires care in choosing a balance between nozzle size and air speed This outcome is agreed with (28).

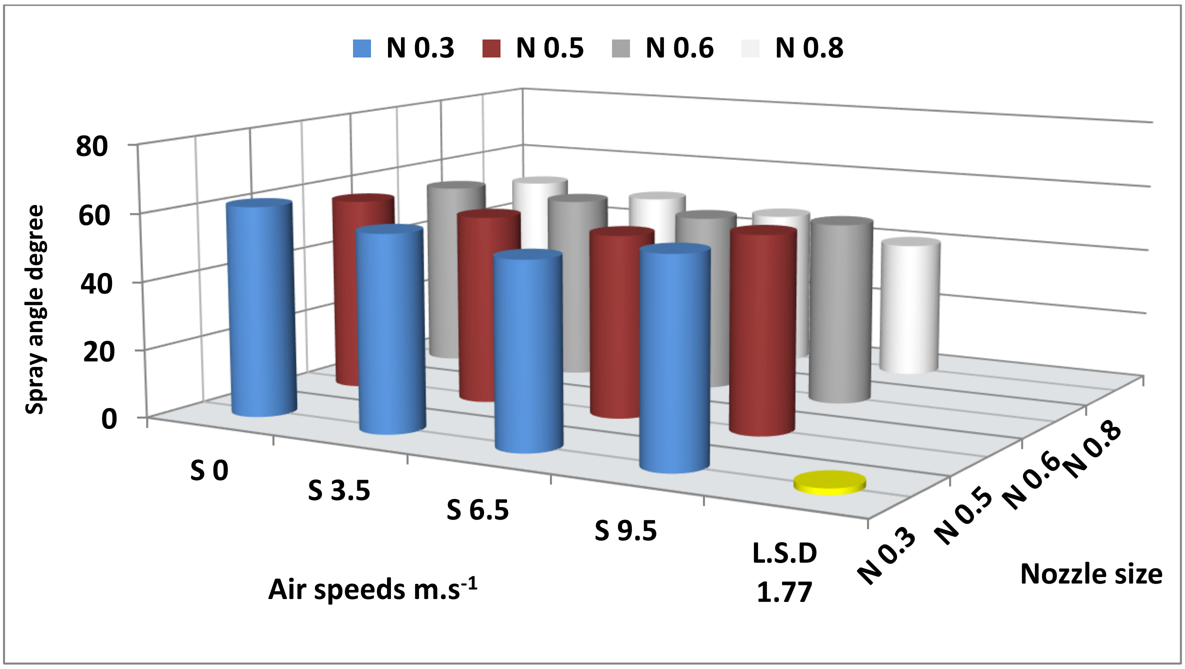

Figure (14): Values of spray angle based on the interaction between nozzle size and air speed. The symbol (N) indicates the nozzle sizes. The symbol (s) indicates the air speeds

4. Conclusion

Based on the obtained data from the current study, it can be concluded that the spray characteristics were significantly affected by the nozzle sizes and air-assisted speeds for all the characteristics studied. The findings illustrated that the nozzle size (0.6) and air speed (6.5 ms^{-1}) are clearly assisted in the increasing of the amount that deposited at a spray width of (0.65 cm) and a spray angle of (52°). This treatment led to the possibility of a noticeable decrease in the spray width. The spraying angle balanced in proportion to the target and reduces the amount of losses in spraying outside the treatment area. The results also

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showed that air-assisted speeds have the greatest effect on spraying characteristics and the amount of losses occurring after spraying process when compared to the nozzle sizes. Despite the increase in the amount of sedimentation per unit area as a result of the factors studied, the study recommends the need to tighten the operational characteristics of the sprayer and carefully choose the balance between nozzle size and air speed to improve the spraying characteristics and reduce the losses as possible.

5. References

(1) Appah, S., Zhou, H. T., Wang, P., Ou, M. X., and Jia, W. D. (2019). Charged monosized droplet behaviour and wetting ability on hydrophobic leaf surfaces depending on surfactant-pesticide concentrate formulation. J. Electrostat. 100. https://doi.org/10.1016/j.elstat.2019.103356

(2) Das, N., Maske, N., Khawa, V., Chaudhary, S.K., Dhete,Er.R.D.(2015). Agricultural Fertilizers and Pesticides Sprayers - A Review. International Journal for Innovative Research in Science & Technology, 1(11): 2349-6010

(3) Alheidary, M.; Douzals, J.P.; and Sinfort, C. (2020). An attempt to reduce spray drift in wind tunnel experimental using substitution nozzles on the boom. CIGR Journal, 22(3): 86-94. https://cigrjournal.org/index.php/Ejounral/article/view/5665/3413

(4) Wei, J., Y. Tang, M. Wang, G. Hua, Y. Zhang and R. Peng. (2020). Wettability on plant leaf surfaces and its effect on pesticide efficiency. International Journal of Precision Agricultural Aviation, 3(1):30-37. https://doi.org/10.33440/j.ijpaa.20200301.62

(5) Sánchez-Hermosilla, J., V. J.Rincón, F.Páez, and M Fernández.(2012). Comparative Spray Deposits by Manually Pulled Trolley Sprayer and a Spray Gun in Greenhouse Tomato Crops. Crop Protection, 31(1), 119-124.

(6)[1](24) Li, J., Li, Z., Ma, Y., Cui, H., Yang, Z., & Lu, H. (2021). Effects of leaf response velocity on spray deposition with an air-assisted orchard sprayer. International Journal of Agricultural and Biological Engineering, 14(1), 123-132.

(7) (23) Wei,Q., Sanqin, Z., Weimin, D., Chengda, S., Jiang, L., Yinian, L., and Jiabing, G. (2016). Effects of fan speed on spray deposition and drift for targeting air- assisted sprayer in pear orchard. International Journal of Agricultural and Biological Engineering, 9(4), 53-62.

(8) Yeary, W., Fulcher, A., Zhu, H., Klingeman, W., & Grant, J. (2018). Spray penetration and natural enemy survival in dense and sparse plant canopies treated with carbaryl: Implications for chemical and biological control. Journal of Environmental Horticulture, 36(1), 21-29

(9) Womac, A. R., Ozkan, E., Zhu, H., Kochendorfer, J., & Jeon, H. (2022). Status of spray penetration and deposition in dense field crop canopies. Journal of the ASABE, 65(5), 1107-1117.

(10) Wei, Z., Li, R., Xue, X., Sun, Y., Zhang, S., Li, Q., ... & Dou, Q. (2023). Research status, methods and prospects of air-assisted spray technology. Agronomy, 13(5), 1407.

(11) (17) Li, T., Qi, P., Wang, Z., Xu, S., Huang, Z., Han, L., & He, X. (2022). Evaluation of the effects of airflow distribution patterns on deposit coverage and spray penetration in multi-unit air-assisted sprayer. Agronomy, 12(4), 944

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https://jam.utq.edu.iq/index.php/main   https://doi.org/10.54174/utjagr.v13i1.323

(12)Kehayov, D., Palagacheva, N., & Zahariev, I. (2020). DETERMINATION THE DEGREE OF COVERAGE WHEN TREATING PEPPER WITH DIFFERENT TYPES OF NOZZLES. Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering, IX, pp. 266- 272

(13) Chethan, C.R., Singh, P.K., Dubey, R.P., Chander, S,. and Ghosh D.(2019). herbicide application methodology influence of nozzl selection, droplet size and spray drift on effective spraying - a review inno. Farm 4(1): 45-53.

(14) Dahri, A. F., & Subr, A. (2023). Evaluating of Different Types of Agricultural Nozzles Locally DOI Used in Iraq. Jornal of Al-Muthanna for Agricultural Sciences, 10(2). 10.52113/mjas04/10.2/23

(15) (19) (27) Xu, S., Wang, X., Li, C., Ran, X., Zhong, Y., Jin, Y. and Song, J. (2023). Effect of airflow angle on abaxial surface deposition in air-assisted spraying. Frontiers in Plant Science, 14, 1211104.

(16) Sayıncı, B. (2014). Effect of filter types and sizes on flow characteristics of standard flat-fan nozzles. Tarım Makinaları Bilimi Dergisi, 10(2), 129-138

(18) Dai, S., Ou, M., Du, W., Yang, X., Dong, X., Jiang, L., & Jia, W. (2023). Effects of sprayer speed, spray distance, and nozzle arrangement angle on low-flow air-assisted spray .deposition. Frontiers in Plant Science, 14, 1184244.

(20) Hussain, A. K., & Alheidary, M. H. (2023). Laboratory determination of spray characteristics using a full hollow cone nozzle at different heights and operating pressures.

(21)[2]Li, S., Chen, C., Wang, Y., Kang, F., & Li, W. (2021). Study on the atomization characteristics of flat fan nozzles for pesticide application at low pressures. Agriculture, 11(4), 309.

(22)Alheidary, M. H. R. (2018). Effect of the operating pressure and nozzle height on dropletproperties using knapsack sprayer. The Iraqi Journal of Agricultural Science, 49(3), 360-366.

(25)Changyuan, Z., Chunjiang, Z., Xiu, W., Wei, L., & Ruixiang, Z. (2014). Nozzle test system for droplet deposition characteristics of orchard air-assisted sprayer and its application. International Journal of Agricultural and Biological Engineering, 7(2), 122-129.

(26)Tian, Z. W., Xue, X. Y., Duan, F. M., Yao, S., & Ma, W. (2022). Automatic system and method for https://doi.org/10.35633/inmateh-68-26improving aerial spray droplet penetration.

(28) Zhu, X., Lewballah, J. K., Fordjour, A., Jiang, X., Liu, J., Ofosu, S. A., & Dwomoh, F. A. (2021). Modelling of water drop movement and distribution in no wind and windy conditions for different nozzle sizes. Water, 13(21), 3006. https://doi.org/10.3390/w13213006