Effect of Nozzle Angle, Size and Pressure on Spray Distribution based on Laboratory Conditions

Nasir Salim Hassen, Nor Azwadi Che Sidik

Abstract: The objective of this study is to investigate spray parameters for different 40°– 95° even flat fan nozzle angles for banding spraying application, such as spray pattern width and spray volumetric distribution at pressures of 2 and 3bar using different nozzle sizes (0.15, 0.2, 0.3, 0.4 gpm). Spray distribution data was extracted from spray analyzer system or patternator. The results showed that nozzle angle and pressure significantly affected the spray pattern width. In addition, as the nozzle size increased, the liquid volume and the peak height under the nozzle center increased. These results suggest that the use of bigger nozzle angles improved the spray volumetric distribution.

Key Words: Banding Application, Nozzle Angle, Pattrenator, Spray Distribution.

I. INTRODUCTION

The most common spraying application found in agricultural fields is broadcast application from conventional boom sprayers. In this type of application, a lot of chemicals are lost in the field that can be caused serious destructive environmental impacts. Spraying application is a complicated task requiring continuous attention to sprayer settings, dynamic variables such as sprayer pressure and weather conditions. It is significant to have tools to monitor the fate of pesticide above the target plant. The use of banding application instead of the broadcasting application improved agrochemical distribution with minimum spray losses [1]. In banding spraying, spray pattern width is the effective sprayed width by a single nozzle spray width [2].

An even distribution of spray liquid is one of the most important indicators of the nozzle performance [3]. Uniformity of spray volumetric distribution is obtained by calibrating the nozzles selected correctly [4]. Researchers and nozzle manufacturers have been especially interested in reducing the percentage of spray losses [5]. Over the last years, a clear growth in means of an instrumentation and assessment for analysing the spray pattern such as carrying out experiments in the laboratory using spray analyzing system or patternator [6].

Revised Manuscript Received on October 05, 2019
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Nozzle angle is the most important factor that affects spray distribution. Different Flat fan nozzle angles are designed and available for different spraying applications. The plane angle formed by the profile of a spray pattern is defined spray angle. Flat fan even nozzle angles are available between 40° - 110° [7]. It could not easy to set nozzle from the spray angle given by the manufacturer. It was noticed that there are deviations between the theoretically calculated spray width and the actual width as result to deviations in the theoretical and actual spray angle of the nozzle [8]. Nozzle pressure is also an important variable in determining spray width and distribution. Increasing of the pressure tend to improve the uniformity of spray distribution [9, 10]. The aim of this study was to provide quantified measurements of the nozzle angle, size and pressure effects on spray parameters of banding spraying application.

II. MATERIALS AND METHODS

A. Selection Nozzles

Spray nozzle selection is very important when efficacy of agrochemical is dependent on coverage. Laboratory tests were conducted in the aeronautics laboratory of the faculty of mechanical engineering, university technology, Malaysia to determine the effect of different 40°– 95°nozzle angle at pressure of 2 and 3 bar on spray pattern width and spray volumetric distribution. The spray nozzles tested for this study were even flat-fan TP nozzles for banding spraying from spraying systems co, Inc. Wheaton, Illinois, USA. Nozzle sizes were of 015, 02, 03 and 04 according to the international organization for standardization (ISO) [11]. Table 1 shows specifications of the selected spray nozzles.

B. Flow rate test

A group of discharge rate tests were conducted for the selected nozzles (L/min) by collecting the water from the nozzle in a container at system pressures of 2 and 3 bar for 1 minute using a 140 L pressurized bottle with a pressure regulator. The spray liquid was tap water. Precision electric balance was used to measure the nozzle output. To validate the results, three times were repeated the tests and the maximum deviation of the nozzle flow rate with the nominal flow rate was ± 2.5%.

Table 1: Specifications of the TP nozzles selected for spraying application

Nozzle code	Nozzle angle (°)	Nominal flow rate (L/min)	
		2bar	3bar
TP95015E	95	0.48	0.59
TP80015E	80	0.48	0.59
TP65015E	65	0.48	0.59
TP40015E	40	0.48	0.59
TP9502E	95	0.65	0.79
TP8002E	80	0.65	0.79
TP6502E	65	0.65	0.79
TP4002E	40	0.65	0.79
TP9503E	95	0.96	1.18
TP8003E	80	0.96	1.18
TP6503E	65	0.96	1.18
TP4003E	40	0.96	1.18
TP9504E	95	1.29	1.58
TP8004E	80	1.29	1.58
TP6504E	65	1.29	1.58
TP4004E	40	1.29	1.58

C. Spray pattern width test

The distance between two spray ends of the nozzle was presented as spray pattern width measurement of the nozzle above the patternator. The nozzle was positioned at spray height of 0.50 m above the center of the patternator. Each test was repeated three times and the results of the spray width were presented as (m) [12].

D. Spray volumetric distribution test

A patternator was used to investigate and identify the volumetric distributions for a single nozzle or groups of nozzles [6, 13, 14]. This system was manufactured with dimensions 300 cm length × 100 cm width spray table. The spray table contains fifty V-shaped gutters (6 cm width ×3 cm depth). During the tests, the spray patternator was inclined 6° from the horizontal plane [12, 15]. A single nozzle was mounted 0.50 m above the centre of the spray table at pressures of 2 and 3bar as shown in Figure 1. Spray nozzle angle, size and pressure combinations were selected randomly. In front of the spray table, a set of plastic tubes (250 mL) was placed to collect the spry liquid from each channel. The weighting method (a precision electric balance) was used to determine the transversal volumetric distributions collected during 1 min. The spray distribution results were recorded as (mL/min). The average of the laboratory conditions for all tests was 30C° and 79% RH.

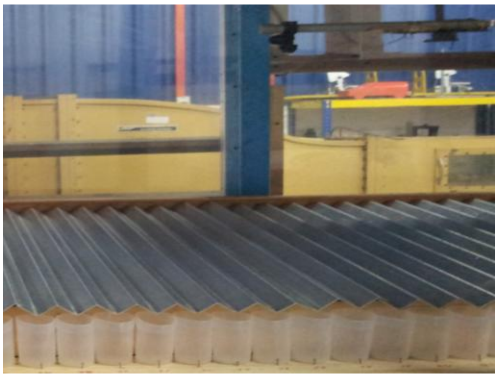

Fig. 1: Patternator for analyzing the spray volumetric distribution

III. RESULTS AND DISCUSSION

A. Spray nozzle pattern width

Table 2 shows the results that can help determine how the nozzle angle should be used to get specific spray pattern width. It can be notice that the bigger angles and higher pressures give wider spray pattern width.

Table 2: Average spray width for different TP nozzle angles and sizes at pressures of 2 and 3 bar.

Nozzle code	Nozzle angle (°)	Average spray pattern width (cm)	
		2bar	3bar
TP95015	95	100	109
TP80015	80	79	83
TP65015	65	60	63
TP40015	40	31	36
TP9502	95	100	109
TP8002	80	79	83
TP6502	65	60	63
TP4002	40	32	36
TP9503	95	106	109
TP8003	80	80	83
TP6503	65	60	63
TP4003	40	33	36
TP9504	95	106	109
TP8004	80	80	84
TP6504	65	60	63
TP4004	40	33	36

B. Static Spray Volumetric Distribution

One of the requirements of the banding spraying is to produce a uniform distribution of the applied liquid on the plant. According to the results, the nozzle angle, size and pressure affect significantly on the spray distribution. Bigger nozzle angles achieved the best spray volumetric distribution in comparison to the smaller nozzle angles in which reduced the differences in the height of the peak under the nozzle centre in comparison to the neighbouring peaks around near to the spray edges. TP95015 nozzle gave the smallest spray peak under the nozzle centre as shown in Figure 2.

Based on the results in Figure 3, nozzle size also affected the spray volume under the nozzle center, increasing of the nozzle size increased the height of the peak under the nozzle center. The effect of a pressure on spray distribution is clear in Figure 4; an increase in the nozzle pressure improves the spray distribution.

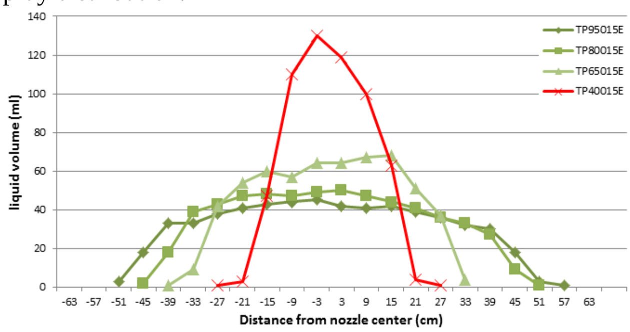

Figure 2: Static spray distribution for different TP nozzle angles at a pressure of 3bar

Retrieval Number: F8254088619/2019©BEIESP
DOI: 10.35940/ijeat.F8254.109119

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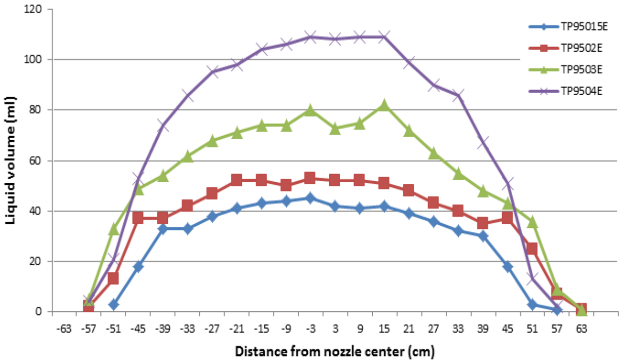

Fig. 3: Static spray distribution for different TP nozzle sizes at a pressure of 3bar

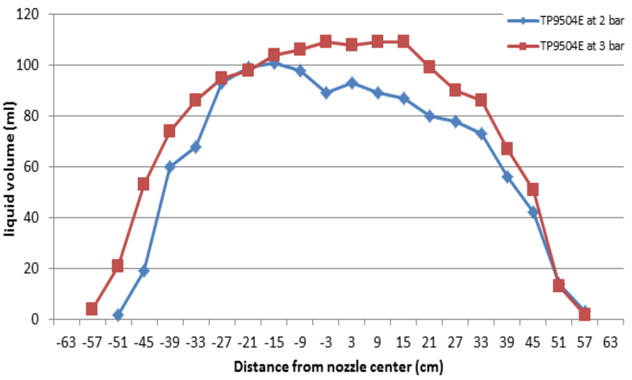

Fig. 4: Static spray distribution for the TP nozzle at pressures of 2 and 3bar

Effect of combination of nozzle angle and pressure on spray volumetric distribution is shown in Figure 5. The best spray distribution was achieved by using bigger nozzle angles at a higher pressure. Figure 6 shows the effect of combination of nozzle size and pressure. The use of small size of nozzles at a higher pressure gave the best spray distribution. Figure 7 shows effect of the triple combination of nozzle angle, size and pressure. The use of smaller size of nozzles with bigger nozzle angle at a higher pressure improves the spray volumetric distribution.

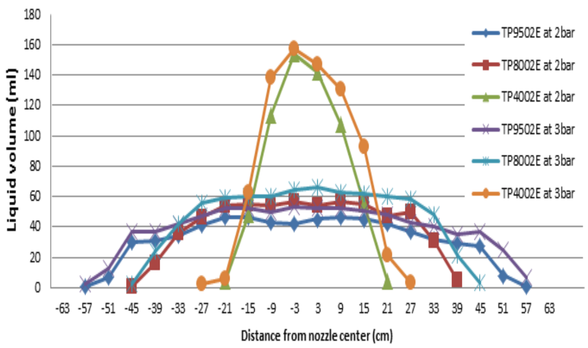

Fig. 5: Static spray distribution for different TP nozzle angles at pressures of 2 and 3bar

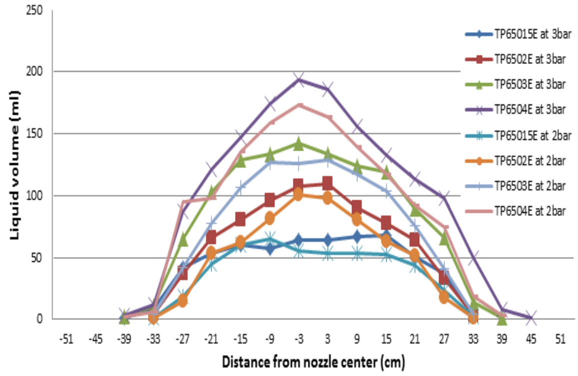

Fig. 6: Static spray distribution for different TP nozzle sizes at pressures of 2 and 3bar

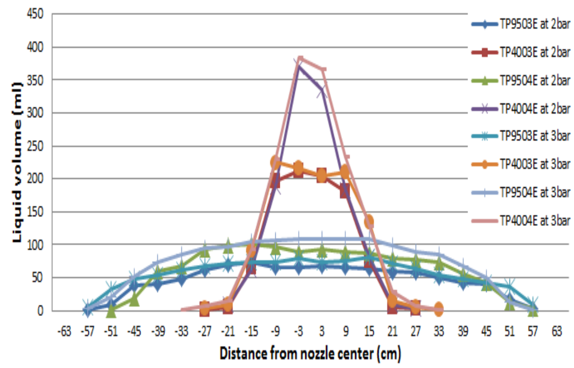

Fig. 7: Static spray distribution for different TP nozzle angle and size at pressures of 2 and 3bar

IV. CONCLUSION

The results of the study showed that the combinations of the nozzle angle, size and pressure affect spray width and distribution. The use of bigger nozzle angles at a higher pressure increases of spray width and improves the spray volumetric distribution. The small sizes of the nozzles gave best control at spray distribution.

ACKNOWLEDGMENT

The authors appreciate all the colleagues and members of the aeronautics laboratory of the faculty of mechanical engineering for direct help to finish this research.

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