Liquid Fertilizer Spraying Performance Using A Knapsack Power Sprayer On Soybean Field

Gatot P\textsuperscript{1} and Anang R\textsuperscript{1}

\textsuperscript{1}Department of Mechanical and Biosystem Engineering, Bogor Agricultural University, Indonesia

E-mail: gph3025818@gmail.com

Abstract. An effort for increasing soybean production can be conducted by applying liquid fertilizer on soybean cultivation field. The objective of this research was to determine liquid fertilizer spraying performance using knapsack power sprayer TASCO TF-900 on a soybean cultivation field. Performances test were conducted in the Laboratory of Spraying Test and on a soybean cultivation field to determine (1) effective spraying width, (2) droplets diameter, (3) droplets density, (4) effective spraying discharge rate, and (5) effective field capacity of spraying. The research was conducted using 2 methods: (1) one-nozzle spraying, and (2) four-nozzles spraying. Results of the research showed that at a constant pressure of 900 kPa effective spraying width using one-nozzle spraying and four-nozzles spraying were 0.62 m and 1.10 m. A bigger effective spraying width was resulted in a bigger average effective spraying discharge rate and average effective spraying field capacity of 4.52 l/min and 83.92 m\textsuperscript{2}/min on forward walking speed range of 0.94 m/s up to 1.77 m/s. On the contrary, bigger effective spraying width was resulted in a smaller droplets diameter of 502.73 μm and a smaller droplets density of 98.39 droplets/cm\textsuperscript{2}, whereas smaller effective spraying width was resulted in a bigger droplets diameter of 367.09 μm and a bigger droplets density of 350.53 droplets/cm\textsuperscript{2}. One-nozzle spraying method produced a better spraying quality than four-nozzles spraying method, although four-nozzles spraying was resulted in a bigger effective field capacity of spraying.

1. Introduction
Soybean (\textit{Glycine max} (L.) Merril) was one of foodstuff that contains protein and it can be supplied to industry and livestock. An effort for increasing soybean production can be conducted by applying liquid fertilizer on soybean cultivation field (Suhaeni 2007). Soybean plant needed effective maintenance because mainly for facing competition with weeds that can decrease soybean production.

Liquid fertilizing can be conducted by applying sprayers to spray it onto soybean leaves. Spraying quality was influenced by some factors i.e. sprayer type, nozzle number, nozzle type, forward speed, spraying direction, and spraying pressure.

Soybean plants were planted on rows with certain distance for each row. A spraying method for the rows was one-way spraying with constant spraying pressure utilized a knapsack power sprayer. A research can be conducted to analyze spraying effectiveness and efficiency by applying some treatments like sum of nozzles and forward speed of spraying. This research can be used to determine liquid fertilizer spraying performance utilized knapsack power sprayer on a soybean cultivation field. The objective of this research is to determine liquid fertilizer spraying performance using a knapsack power sprayer on soybean field.
2. Materials and methods
The research was conducted from February 2017 to June 2017 in the Laboratory of Spraying Test and on a soybean cultivation field to determine (1) effective spraying width, (2) droplets diameter, (3) droplets density, (4) effective spraying discharge, and (5) effective field capacity of spraying as seen in figure 1.

Figure 1. Research method to determine liquid fertilizer spraying performance utilized knapsack power sprayer

The tools which were used in this research are knapsack power sprayer TASCO TF-900 and some spray performance measuring instruments such as patternator, timer, scales, measuring cup, and tape meter. The materials used were liquid fertilizers, pipes, clean water, ink, concord paper, and glue.

The research was conducted using 2 methods: (1) one-nozzle spraying, and (2) four-nozzles spraying. The one-nozzle spraying was given from original product, whereas the four-nozzles spraying was made from modification result. All nozzles which are used in this research are solid cone nozzles with funnel as seen in figure 2.
Figure 2. An example of a solid cone nozzle with funnel

Determination of spraying performance parameters in the Laboratory of Spraying Test is important to do before it is applied on a soybean cultivation field as seen on figure 3. This research is mainly used for effective spraying width (ESW) determining.

Figure 3. One-nozzle (left) and four-nozzles (right) spraying on patternator in the Laboratory of Spraying Test

Liquid fertilizer spraying will be more effective with finer droplets size (droplets diameter) and higher droplets density. Smaller droplets diameter and higher droplets density make this condition met so that the effectiveness of liquid fertilizer spraying by using a knapsack power sprayer will be achieved.

Efficient liquid fertilizer spraying is also important in order to save time and money. This can be achieved with quick and cheap liquid fertilizer application. In order to achieve it, no repeated application is advised, droplets distribution during the application time is done once only, and the volume of droplets applied is not excessive. This condition is met if the effective spraying width (ESW) and forward speed of spraying (FFS) are high and effective spraying discharge rate (ESD) is low (economical). In other words, liquid fertilizer spraying will be more efficient (short application time and economical application cost) if ESW and FFS are high and ESD is low. It is noted when ESW and FFS are high, so it will result in high effective field capacity of spraying (EFC).

Optimization of liquid fertilizer spraying needs to be done in so that it can be done optimally (effective and efficient). Optimal spraying is achieved with if liquid fertilizer has the following requirements: (1) minimum droplets diameter, (2) maximum droplets density, (3) maximum ESW, (4) minimum ESD, and (5) maximum EFC. These five parameters of effectiveness and efficiency of liquid fertilizer spraying can be measured in the Laboratory of Spraying Test and on a soybean cultivation field as seen on figure 4.
3. Results and discussion
Results of the research showed that at a constant pressure of 900 kPa effective spraying width using 1-nozzle spraying and 4-nozzles spraying were 0.62 m and 1.10 m, respectively. This result described that the increment of sum of spraying nozzles would result in wider effective spraying width. An example of spraying pattern result to determine effective spraying width can be seen on figure 5.

Effective spraying discharge rate on soybean field was vary on various forward walking speed. Effective spraying discharge rate decreased by increasing forward walking speed. Average effective spraying discharge rate of 4-nozzles spraying method was bigger than average effective spraying discharge rate of 1-nozzle method (figure 6). Effective spraying width of 4-nozzles spraying was bigger
than 1-nozzle spraying, so it caused a bigger spraying volume that resulted in increasing effective spraying discharge rate.

![Figure 6](image-url)

**Figure 6.** Effective spraying discharge rate on various forward walking speed

Effective spraying field capacity increased by increasing forward walking speed on soybean field and it also increased by increasing the number of nozzle. It can be seen on figure 7.

![Figure 7](image-url)

**Figure 7.** Spraying effective field capacity on various forward walking speed

Different number of spraying nozzle produced different droplets diameter and droplets density. One-nozzle spraying produced smaller droplets diameter than four-nozzles spraying. It also produced bigger droplets density than four-nozzles spraying. Visualisation and value of droplets diameter and droplets density can be seen on figure 8 and figure 9.
A bigger effective spraying width of 1.10 m was result in a bigger average effective spraying discharge rate of 4.52 l/min and an average effective spraying field capacity of 83.92 m²/min on forward walking speed range of 0.94 m/s up to 1.77 m/s. On the contrary, bigger effective spraying width was result in a bigger droplets diameter of 502.73 μm and smaller droplets density of 98.39 droplets/cm², whereas smaller effective spraying width was result in smaller droplets diameter of 367.09 μm and bigger droplets density of 350.53 droplets/cm². Based on the ASABE S572.1 droplets size classification (table 1), it can be said that droplets diameter of 502.73 μm was classified as very coarse spray quality, whereas droplets diameter of 367.09 μm was classified as coarse spray quality.

Droplet diameter and droplets density determined quality or effectiveness of spraying, whereas effective spraying field capacity determined spraying efficiency. One-nozzle spraying method showed better spraying quality than four-nozzles spraying because it had smaller droplets diameter and had bigger droplets density than four-nozzles spraying, although four-nozzles spraying was result in bigger effective spraying field capacity.
4. Conclusions
It was concluded that spraying utilized knapsack power sprayer with one-nozzle produced effective spraying width of 0.62 m, average effective spraying discharge rate of 3.38 l/min, and average effective spraying field capacity of 48.97 m²/min. Spraying utilized knapsack power sprayer with four-nozzles produced effective spraying width of 1.10 m, average effective spraying discharge rate of 4.52 l/min, and average effective spraying field capacity of 83.92 m²/min.

A bigger effective spraying width was result in bigger droplets diameter of 502.73 μm (very coarse spray quality) and smaller droplets density of 98.39 droplets/cm², whereas smaller effective spraying width was result in smaller droplets diameter of 367.09 μm (coarse spray quality) and bigger droplets density of 350.53 droplets/cm². One-nozzle spraying method produced better spraying quality than four-nozzles spraying method, although four-nozzles spraying was result in bigger effective spraying field capacity.

References
[1] Kurniawan T 2014 Modification number nozzle of motorized knapsack sprayer and nozzle performance test at various type and pressure (in Indonesian) (Bogor: Bogor Agricultural University)
[2] PES 2017 ASABE S572.1 Droplet Size Classification. Pesticide Environmental Stewardship. https://pesticidesstewardship.org/pesticide-drift/understanding-droplets-size/ [accessed on 01 January 2018]
[3] Suhaeni N 2007 Practical Guide to Planting Soybean (in Indonesian) (Bandung: Nuansa)
[4] Yuwana NAJ. 2014. Design and Construction of Grid Patternator for Sprayer Spray Performance Test (in Indonesian) (Bogor: Bogor Agricultural University)

Table 1. ASABE S572.1 Droplet Size Classification (PES 2017)