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Short Communication

Study on Water Distribution of Spraying Drone by different Speed and Altitude

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Abstract: The application of unmanned aerial vehicles (UAV) in Malaysia, or best known as a drone, is changing from time to time. Today, drones are used not only in the military, but also in agriculture. The use of drones became common in agriculture due to a reduction in cultivated land, labour shortages and obsolete methods. The spraying of pesticides and herbicides may also be carried out using drones. Furthermore, the time-consumed using drone is faster compared to the conventional method. On the market, there are different kinds and types of drone sprayers. Although the manufacturer has set the Standard Operating Procedure (SOP) for drone usage, the efficacy of spraying should first be examined because of Malaysia's weather and environmental factors which vary from other countries. The purpose of this paper is to investigate the effects of altitude and speed of the drone onto the coverage area during spraying application. In this study, a plot consisting of 0.5 Hectares situated at MARDI Seberang Perai was used. Three different speeds of 2 m/s, 3 m/s, and 4 m/s and three altitudes measured in heights of 1.5 m, 2.0 m, and 2.5 m from the top of the crop were tested. Wind speed and direction were recorded using an anemometer during the study. Water-sensitive paper was used during the experiment to examine the effect on spraying. In order to calculate the coverage area percentage, the spraying effect on water sensitive paper was analysed using ImageJ software. The results are expected to show which speed and altitude may contribute to the largest area of coverage percentage. The appropriate altitude and speed for the spraying operation on the basis of crop requirements can be concluded from the result which is 2 m from above crop at speed of 2.5 m/s.

Keywords UAV; Drone sprayer; spraying; pesticide; herbicide

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1. Introduction

Unmanned Aerial Vehicle (UAV) or otherwise known as drone is a type of aircraft which is either remotely operated by an operator or automatically moved to the pre-programmed route without a pilot on-board (Berner & Chojnaki, 2017). Drones have been used for tree monitoring, livestock growth, disease control, weed, and pesticide control in agriculture. Drone technology is able to provide farmers with low-cost monitoring of their plants from the air. In addition, any information can be collected more easily and reliably through field monitoring which can be achieved more quickly using drone technology. The new drone technology is not only for crop surveillance, but can also be utilised for payload distribution, including the use of pesticides and herbicides (Giles & Billing, 2015). This in turn minimises labour shortages and improve the efficiency of spraying. It may also reduce the risk of pesticide and herbicide poisoning (Kedari *et al.*, 2016).

Several companies offer UAV spraying services for herbicides and pesticides, but to the best of our knowledge, there are still no sufficient studies to evaluate the effectiveness of drone spraying. Hence, the purpose of this experiment was to determine the effects of altitude and speed of the drone onto the coverage area during the spraying application.

2. Material and Method

2.1 Plot Layout

The experiment was conducted in MARDI Seberang Perai. The experimental plot size was 5 m x 15 m. The spacing between columns was 1 m while between rows was 5 m. The water-sensitive paper was used to trace the droplet from the drone sprayer. The papers were placed in rows of three where each row had five pieces. The layout of the plot is shown in Figure 1 below.

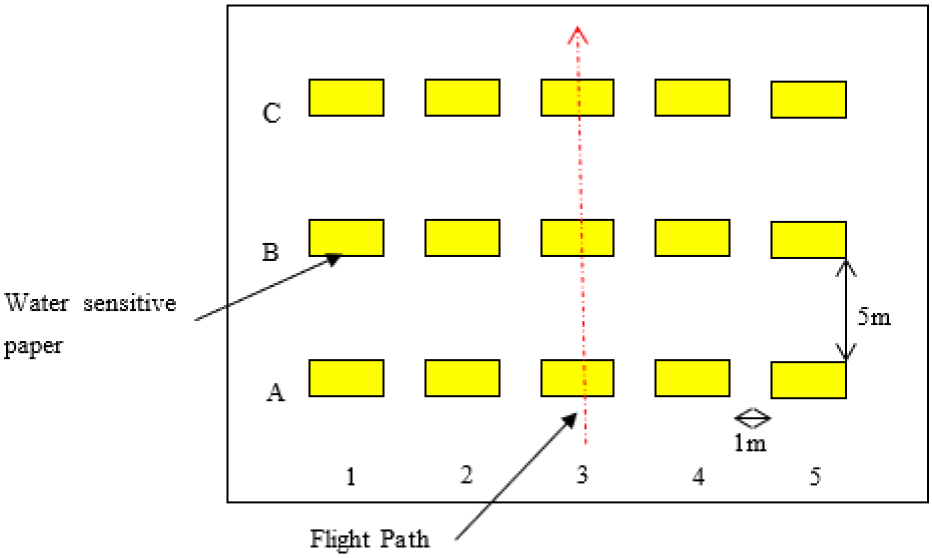

Figure 1. The experiment layout.

2.2 Materials

The drone used for spraying during the experiment was the Agras MG-1S from DJI, as shown in Figure 2. It is an eight blades type drone with 10 litres tank capacity. Additionally, the drone also consists of 4 fan type nozzles below its propeller. The drone was powered by a 12000 mAh lithium polymer battery. This drone has three modes of spraying, which are the fully automatic, semi-automatic, and manual modes. In the fully automatic mode, settings of the flight path, altitude, and speed were first needed to be carried out, and thereafter, the drone will fly automatically according to the designated path. In the semi-automatic mode, settings of the altitude and the speed of the drone during spraying can be made, while in the manual mode, everything needs to be controlled manually. The water-sensitive paper from Sygenta was used in this experiment to trace the droplet from the spraying drone.

Figure 2. DJI Agras MG-1S Drone sprayer.

2.3 *Experimental method*

The experiments were conducted 14 days after sowing (DAS), and the variety of the paddy used in this experiment was CL1. Normal tap water was used in the experiment. The water-sensitive paper was used to trace and evaluate the spray distribution assessment (Salyani *et al.*, 2013) and was analysed using an image analysis method (Hoffman & Hewitt, 2005). This 3x2-inch paper was arranged according to the layout set in the plot. The water-sensitive papers, as shown in Figure 4, were placed on top of the canopy. The spacing was set at 1 m for each column. At a height of 1.5 m, 2.0 m, and 2.5 m from the crop, a total of three flight speeds of 2 m/s, 3 m/s and 4 m/s were tested. The flight path of the drone is as shown in Figure 1. For each experiment, wind velocity and direction were recorded. Air velocity, temperature and relative humidity were measured using a digital anemometer and a digital thermometer, respectively. For each treatment, atmospheric conditions were recorded. After the experiment, in order to determine the area covered by the droplet, the effect of the water sprayed on water-sensitive paper was analysed using ImageJ software (Mangadoa *et al.*, 2013). Figure 3 shows the examples of images that have been analysed. Using Design Expert statistical analysis tools, the result from the image was then statistically analysed to determine which height and speed would achieve the highest coverage area.

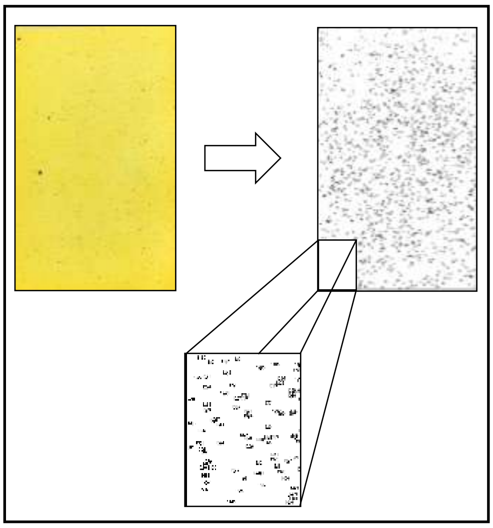

Figure 3. Examples of water-sensitive paper before (left) and after analysed (right).

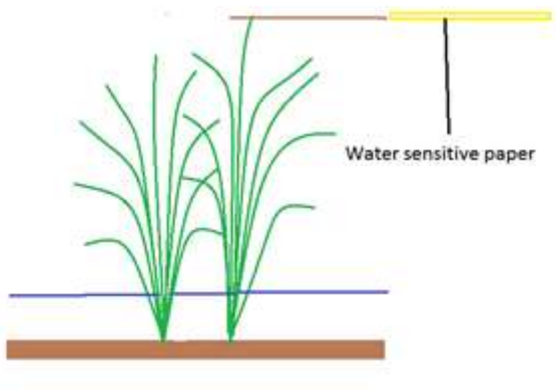

Figure 4. The position of water sensitive paper at the crop

3. Results and Discussions

The experiments were conducted from 8.30 am to 11.00 am. The temperature recorded during the experiment was between 28.2℃ to 33.6℃ while wind speed was between 0m/s to 3 m/s. The relative humidity was recorded at an average of 76%. The experiment was conducted in the morning, where the wind speed was not too high and suitable for spraying activity. According to the Qi *et al.* (2018), humidity conditions have to be anticipated in order to have a stronger impact on droplet size, coverage, deposition volume, and deposition density, since the droplet size, coverage, deposition volume, and deposition density increase with rising humidity. Additionally, at temperature between 10℃ to 29℃, the effect of the temperature to the droplet deposition is insignificant.

Table 1 shows the ANOVA analysis for the correlation between speed and altitude of the drone to the coverage area percentage recorded by the water-sensitive paper after analysis using ImageJ software.

Table 1. ANOVA for Reduced Cubic model.

Response 1: Coverage
Transform: Natural Log
Constant: 0

Source	Sum of Squares	*df*	Mean Square	*F*-value	*p*-value	
Model	31.22	7	4.46	39.26	< 0.0001	significant
B-speed	8.44	1	8.44	74.26	< 0.0001	
A^2	1.27	1	1.27	11.18	0.0086	
B^2	2.59	1	2.59	22.77	0.0010	
A^2B	5.31	1	5.31	46.71	< 0.0001	
Residual	1.02	9	0.1136			

Source	Sum of Squares	*df*	Mean Square	*F*-value	*p*-value	
Lack of Fit	0.9041	5	0.1808	6.11	0.0520	not significant
Pure Error	0.1183	4	0.0296			
Cor Total	32.24	16				

Note: A Height; B = Speed

From Table 1, the model was significant at F value = 39.26 and p = 0.0001 level. P-values less than 0.05 indicated that the model terms were significant. In this case, p-value of B = 0.0001, A^2 = 0.0086, B^2 = 0.001 and A^2B = 0.0001 were significant model terms. Lack of fit p value > 0.05 showed that the model predicted data fit to actual experimental response data. The data then were analysed using Design Expert statistical software to determine the best height and the best drone speed for spraying application.

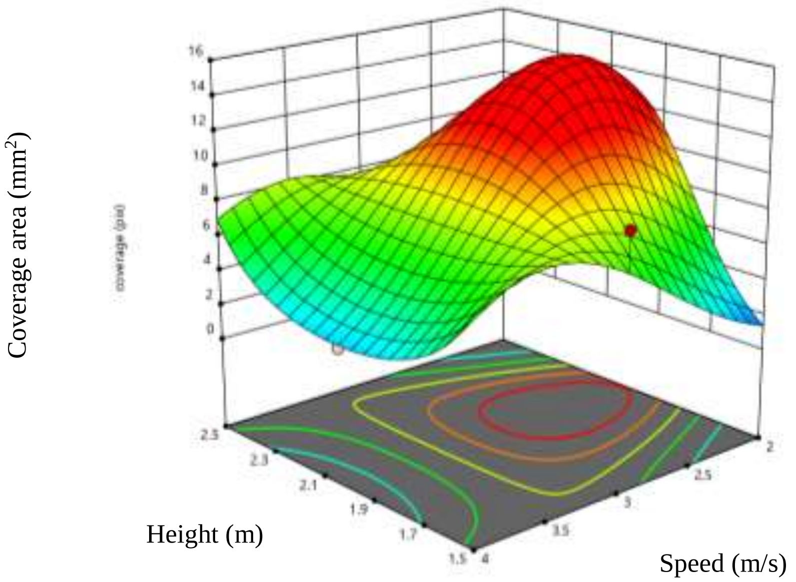

Figure 5. 3D graph for speed vs height vs coverage area

Figure 5 shows the 3D graph of speed vs. height vs. coverage area. From the graph, it was shown that the maximum coverage area can be obtained at a speed of 2.5 m/s with a height of 2 m. The ideal speed and height of the drone during spraying application is important to ensure uniformity during spraying and also to ensure that the applied chemical is not off targeted. According to Martin *et al*. (2019), the drone spraying swath was significantly influenced by height.

4. Conclusion

The purpose of this paper was to investigate the effects of alttitude and speed of the drone onto the coverage area during spraying application. From the result, the maximum coverage area can be obtained with a speed of 2.5 m/s and at the height of 2 m from the crop. This study is important because both speed and height of the drone affect the coverage area during spraying application. Spraying drift may easily occur if the spraying altitude is too high from the crop and can be off-target (Lou *et al.*, 2018). This may cause wastage of chemicals and can also contribute to the pollution of the surrounding areas to the plot. In addition, the drones cannot be flown too fast because it may also affect the coverage area. Future study needs to be carried out using actual herbicide and pesticide in order to study the efficacy of the actual chemical sprayed with a drone using the finding from this work.

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Conflicts of Interest: The authors declare that there is no conflict of interest

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