Paper No :

MSAE2018-ARWM012

Evaluation of the Spraying Dispersion and Uniformity Using Drone in Rice Field Application

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ABSTRACT

Spraying operation in a rice field is considered as the most harmful operation since the operator has to deal with the toxic chemicals and prolong and frequent exposure. Drone provides an effective method for such operation by reducing time of operation at least about one-third compared to the conventional. The test was conducted in the rice field, tested for uniformity and drift effect from using drone versus knapsack sprayer methods. About 1000 samples were collected for all treatments imposed. The uniformity of the spraying at 2 m height using drone is similar as using knapsack sprayer, with CV value at 0.46 and 0.43, respectively. Both methods of spraying causes a drift to travel up to 25 m away from the spraying source. Flying height between 1.5 m and 2 m from the crop canopy is suggested to be the best considering best uniformity pattern and at minimum drift could occur. This study is expected to provide an information and recommendation of the effectiveness by means of drone for spraying operation in rice production. The impact is not only for the food safety and security, but also for the farmer's income by reduction of the production cost.

KEYWORDS

Drone, UAV, UAS, Rice, Spraying, Uniformity, Drift effect, Environmental effect.

Paper presented at the 2018 MSAE Conference, Serdang, Selangor D. E., Malaysia. 7 & 8 February 2018

INTRODUCTION

Rice production annually contributes to almost 3 million MT national consumption. However, arable land for rice production is reduced due to land conversion to non-agriculture activities. Thus, in order to keep up with the same production level, management reformation and utilization of the technology is necessary for better farm management. Muazu et al. (2015) reported that the calculated average overall mechanization index for wetland paddy production on North-West Selangor is 0.92. This calculated overall index indicates that the current mechanization status of the Wetland Paddy Production System is very high with a ratio value that is closed to 1. However, the three critical field operations in the order of importance for mechanization are fertilized with a mechanization index of 0.17 followed by spraying and seedling with an index of 0.19 and 0.25, respectively. Tillage, harvesting and slashing operations could be currently considered being almost fully mechanized having indexes above 0.94. Similarly, Nawi et al. (2012) found that the spraying pesticide operation in the rice field cultivation is one of the most tedious operations and the most energy consuming, accounted for about 56% of the overall rice field operation. Under this activity, the mixing the liquid, and walking in the wet and muddy field were monitored for the pesticide application using knapsack power blower unit.

In addition to that, Muazu et al. (2015) reported that both fertilizing, and spraying operations constituted about 63.42% of the total cost expenditure in North-West Selangor (i.e. 36.78% in fertilizing and 26.64% in spraying). An average paddy farmer there spent relatively very high investment of about RM1436.51 per ha per season for the fertilizing operating cost was about RM1040.49 per ha per season for the spraying operation. Thus, decreasing the operating costs for both fertilizing, and spraying operations would promise for a better average gross margin to the current paddy farmers in Malaysia. Spraying operation in a rice field is considered as the most harmful operation since the operator has to deal with the toxic chemicals and prolong and frequent exposure. With the cost uncertainty near future of the pesticide product and the labor, there is a need to find a cheaper and effective method for the spraying effectively. In such alternative, the drone spraying system has been adopted. The drone was designed to fly at low altitude of several meters, the spraying effect can be controlled in the active area (Huang et al., 2008). The issues, possibly raised from the used of drone in the rice field will be regarding the environmental impact in term of the drift (Xinyu et al., 2014, Morshed et al., 2014, and Weppner et al., 2006) to the operator or residential area, as well as a calibration procedure for a specific liquid used at a desired rate of application (Faiçal et. al., 2014). However, the effectiveness of the drone in pesticides spraying in rice production operation is yet to be confirmed and required further research which is the main focus of this research.

Therefore, the objective of this study was to conduct a test for the spraying effectiveness, namely for spraying distribution and drift effect by using drone versus a knapsack sprayer method. This study is expected to provide an information and recommendation of the effectiveness by means of drone for spraying operation in rice production. In future, sustainable rice cultivation must also be embedded in the current practice with the use of less pesticide application. The impact is not only for the food safety and security, but also for the farmer's income by reduction of the production cost.

MATERIALS AND METHODS

Study area

This study was conducted at the *Kompleks Latihan MADA Alor Serdang*, Kota Sarang Semut, Lembaga Kemajuan Wilayah Muda (MADA), Alor Setar, Kedah during season 1, 2017. About 1 ha area was allocated for the drone test in the field. The crop was at about 80-90 days after transplant. The average wind speed during the test for both; drone and knapsack sprayer was at relatively calm weather with an average wind speed is at 1.2 km/hr. The average ambient temperature was about 27.5°C, and average relative humidity was at 84%. These weather data were retrieved from nearby weather stations at 1 min interval, located about 15 m away from the test location. The field test was conducted from 9am to 1130am and continued at 5pm until 7pm. The drone used for this study is from DJI drone, (Model: Agras-1) as in figure 1. It's being controlled at the desired test height and at typical speed (5-8 km/hr).

ISBN 978-967-16145

Figure 1: The pilot operates the DJI Agras-1 with semi-automatic control mode at the required flying height, deployed to perform the spraying test

Test procedure and data collection

The test was conducted for the spraying distribution and spray drift by comparing using drone versus a knapsack sprayer. The drone was tested at three different heights (1.5, 2.0 and 2.5m) and about 0.15 m by using knapsack sprayer. Drone spraying pattern covers both vertical and horizontal direction due to strong downwash from the drone fans. However, the knapsack sprayer only applies the horizontal direction. The liquid used to be the mixture of the water and florescent, acting as an active ingredient. A cotton cloth was placed for every sub meter for distribution test, and three cloth samples at different height up to the distance of 25 m from the spraying line, with 5 m apart (Figure 2). The latter procedure is for the drift test. The test for the spraying uniformity was repeated 5 times, and three drift posts were located on both sides of the test., with each line consisted of six posts. As the result, about 1000 samples were collected and brought to the lab for fluorometer analysis. The coefficient value (CV) was used to test for the accuracy and consistency of the data. This analysis was conducted using Microsoft Office software.

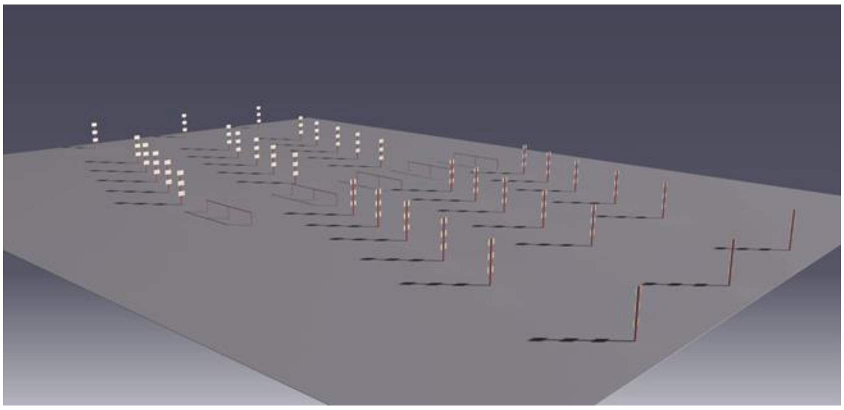

Figure 2: The sketch layout of the test post location for the distribution and drift study.

RESULTS AND DISCUSSIONS

The spray distribution is not uniform for both drone and knapsack sprayer. However, the knapsack sprayer performs better with lower coefficient value (CV) than using drone as shows in Table 1 below. However, the amount of deposits using knapsack sprayer is lower than using drone. This may due to different nozzles used during the test. The uniformity of the spraying at 2 m height using drone is similar as using knapsack sprayer, with a CV value at 0.46 and 0.43, respectively. The uniformity of the spraying could be improved by arranging the nozzle in-line position as opposed to what currently designed on the tested drone. Both methods of spraying cause a drift to travel up to 25 m away from the spraying source.

ISBN 978-967-16145

Further study is required to see how far the drift could travel. This also will reflect to the viscosity of the liquid used during the spraying. Flying height between 1.5 m and 2 m from the crop canopy is suggested to be the best considering best uniformity pattern and at minimum drift could occur. However, this will be depending upon the design of the drone used as well as the downwash created by the drone rotors.

Table 1: Distribution and drift results of the field test. The values are the average values for each category. (Std. Dev = Standard deviation, CV= Coefficient of variation)

Test parameter	Mean (ng/cm^2)	Std. dev.	CV
Field test-Deposition			
Deposited rate at 1.5 m	0.5538	0.3518	0.6352
Deposited rate at 2.0 m	0.1890	0.0879	0.4650
Deposited rate at 2.5 m	0.1981	0.1158	0.5847
Deposited rate blower (lateral application)	0.1397	0.0600	0.4296
Field test -Drift			
Deposited rate at 1.5 m	0.0052	0.006	1.118
Deposited rate at 2.0 m	0.0033	0.001	0.215
Deposited rate at 2.5 m	0.0043	0.002	0.512
Deposited rate blower (lateral application)	0.0046	0.001	0.191

CONCLUSIONS

Other than external factors such as wind speed and ambient temperature, the uniformity of the spraying using drone method is significantly affected by the flying height, however, it's a tradeoff for the drift effect. Further study is required in order to see the effect of more components affecting the uniformity and minimized the drift effect.

ACKNOWLEDGEMENT

This study was supported by grants from Lembaga Kemajuan Wilayah Muda (MADA). The authors would like to thank Mr. Ahmad Sukri Saad, Mr. Mohd Fadzil Mat Desa, Mr. Mohammad Ashraf Mohamad Puzi for their assistance in completing this project. Assistance from graduate students involve in this project is appreciated.

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