Preliminary Study on Pesticide Application in Paddy Field using Drone Sprayer

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Abstract: The usage of Unmanned Aerial Vehicles (UAV) or drones in agriculture is still new in Malaysia. There are very few studies to determine the effectiveness of spraying chemicals using a drone that can suit the weather and environmental factors in Malaysia. This paper aims to investigate the efficacy of the pesticide application using a drone sprayer in a paddy field. The plot is 0.5 hectares located at MARDI Seberang Perai. The study was done from June until November 2019. The pesticide application was carried out 4 times which was 32 days after sowing (DAS), 46 DAS, 70 DAS, and 102 DAS. There were two types of chemicals used in this experiment, which were used to control the pesticide and the disease. The study involves two methods of chemical application, which were drone and knapsack applications. The number of pesticides and percentages of disease attacks was taken within 1 week before and after spraying. From the results, the application of the drone on pesticides spraying was not any different with manual application with the current normal practices nowadays. Rice farmers have the option to choose what application to use in their field to control insect pests. In this, they have to consider the cost, availability, field and hazardous conditions. However, to get a better result, this experiment should be repeated during suitable seasons.

1. Introduction

Unmanned Aerial Vehicle (UAV) or otherwise known as a drone is a type of aircraft that moves, without a pilot on-board where the aircraft is either remotely controlled by the operator or move automatically according to a pre-programmed flight path (Berner & Chojnacki, 2017). Drones have been used in various fields such as in the military, mapping and also in agriculture. In agriculture, drones have been used for monitoring tree and livestock growth, disease control, weed and pesticide control. In precision farming, drones are used to replace planes and satellites in the remote sensing of plants (Pinter *et al.,* 2003). Drone technology helps farmers to monitor their plants from the air at a low cost.

Drones became very popular in agriculture due to reduction in cultivated land, labour shortage and outdated conventional methods (Reddy *et al*., 2017). By using a drone, field monitoring can be done more rapidly and more information can be obtained in a short period and more accurate. Current drone technology is not only for crop monitoring but also for carrying payloads including the application of pesticides and herbicides (Giles & Billing, 2015). Thus, this technology can reduce the shortage of labour and increase spraying efficiency. Furthermore, the risk of having pesticide and herbicide poisoning also can be reduced (Kedari *et al*., 2016; Vardhan *et al*., 2014). For pest and disease control, the advantage of using a drone is that it can be performed in a short period of time without destroying the soil and the crop (Berner & Chojnacki, 2017). Besides, drones can move quickly over the field crops and can easily adjust the spraying height above the plants (Faiçal *et al.*, 2017).

There are several service providers that provide services for spraying herbicides and pesticides using drones but there are still no proper studies to show the efficacy of drone spraying. The objective of this experiment is therefore to study the efficacy of chemical application in the paddy field using a drone.

2. Materials and Methods

2.1 *Plot Layout*

The experiment was conducted in MARDI Seberang Perai. The size of the plot was 0.5 hectares and was divided into 24 sub-plots consisting of plots for drone single and mixture chemical spraying and knapsack single and mixture chemical spraying. The arrangement of the subplots are completely randomised plot. The location and layout of the plot are shown in Figure 1 and Figure 2.

Figure 1. Plot location in MARDI Seberang Perai.

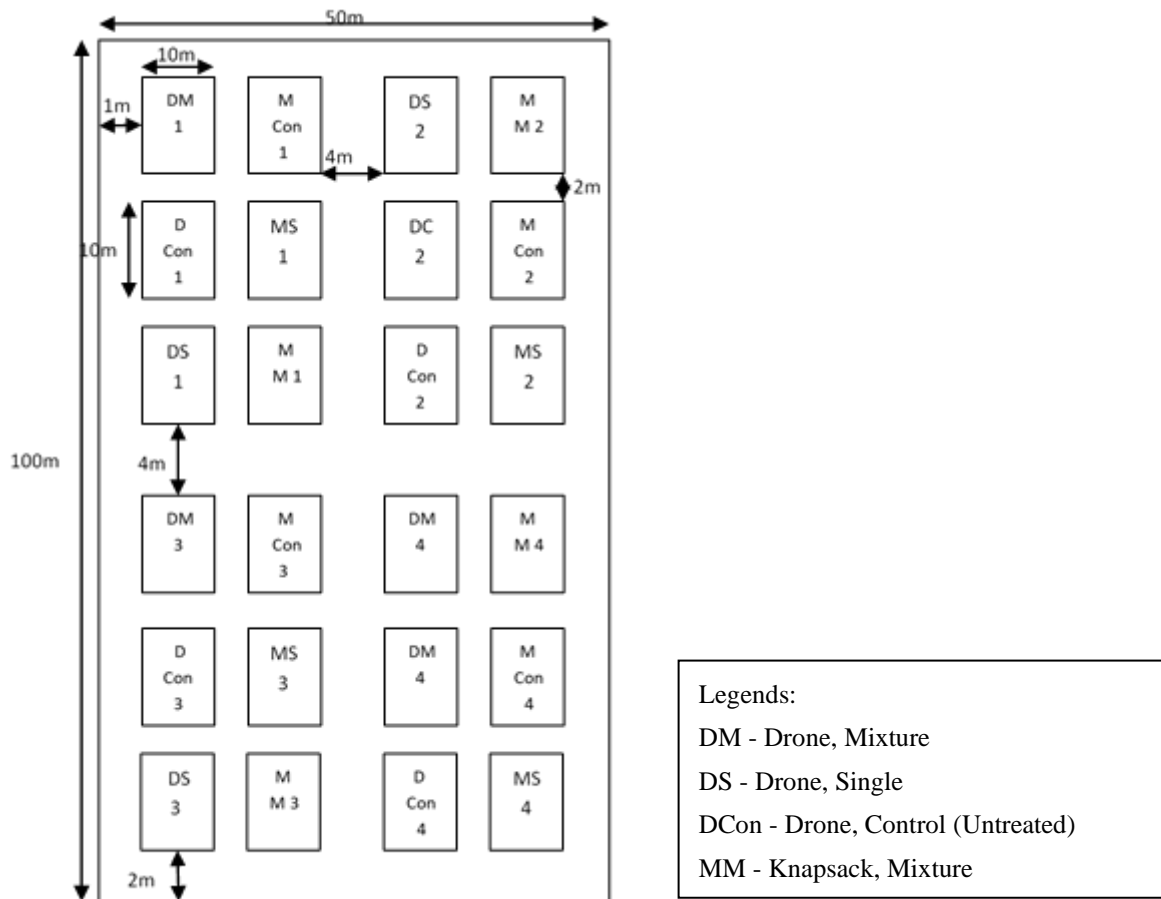**Figure 2.** Plot layout.

2.2 *Materials*

The drone used in the experiment is from DJI Agras MG-1P as shown in Figure 3. It is an 8 blades type of drone with a 10 L tank capacity. It consists of 4 fan type nozzles located below its propeller. The drone is powered by a 12000 mAh lithium polymer battery. The advantages of using this type of drone are in its features where it does not require an airport

to take off and landing compared to a conventional airplane, it can hover and turn around flexibly due to the short turning radius of the UAV, able to fly stably at super-low altitude and easy to control due to the intelligence technology of autopilot (Xiongkui *et al*., 2017; Huang *et al*., 2013). The knapsack motorised sprayer used in this experiment is B&S BSK220206 as shown in Figure 3. The knapsack sprayer is powered by a 26 cc two-stroke engine. The capacity of the tank is 20 L. and the maximum flow rate is 7 L/hour.

Figure 3. Drone sprayer DJI Agras MG1-P and B&S BSK220206 knapsack motorized blower.

2.3 Experiment method

The chemical applications were conducted 4 times throughout the experiment which was 32 days after sowing (DAS), 46 DAS, 70 DAS and 102 DAS. The layout of the experiment is shown in Figure 2. The chemicals used in this experiment are as shown in Table 1. The active ingredients contain in the chemicals are suitable to control the targeted disease (Azmi *et al*., 2008). For drone spraying, the spraying rate used in this experiment was 20 L/ha which consisted of water and chemicals while for knapsack spraying the chemicals are as mentioned in Table 1. The speed of the drone used was 4m/s. Spraying altitude was determined at 1.5 m above the crop and the wind speed must be between 1.0 m/s to 3.8 m/s (Hussain *et al*., 2019). There were two types of chemicals applied for each experiment. Between these two types of chemicals, 4 types of experiments were conducted which were drone sprayer with a single chemical, drone sprayer with a mixture of the two chemicals, knapsack motorised sprayer with single chemical and knapsack motorised sprayer with mixture chemical. Spraying time for drone and knapsack motorized sprayer were recorded for each experiment as shown in Table 2.

Table 1. List of pesticide applications, target pests and diseases and active ingredients of insecticides/fungicides.

DAS	Experiment	Target	Active Ingredient	Spraying Rate Per Hectare (Chemical volume/ water volume)
32	1	Caseworm/leaf folder	Cartap Hydrochloride 50%	1.28kg/280l
		Foliar blast	Axoxystrobin	0.75l/200l
46	2	Caseworm/leaf folder/ stem borer	Fipronil 5%	0.75l/200l
		Sheath blight	Difenokonazol	0.3l/300l
70	3	Leaf folder/ stem borer/brown plant hopper	Klorantraniliprol 20% + tiametoksam 20%	0.2l/180l
		Sheath blight/Panicle blast	Trifloxystrobin Tebuconazole	75g/250l
102	4	Rice bug	Fenthion 50%	300ml/300l
		Panicle blast	Axoxystrobin	0.75l/200l

Table 2. Spraying time for each experiment.

Treatment	Experiment 1 Spraying time (s)	Experiment 2 Spraying time (s)	Experiment 3 Spraying time (s)	Experiment 4 Spraying time (s)
DS1-1	22.4	19.17	14.76	19.37
DS1-2	27.68	16.26	14.35	15.9
DS1-3	23.32	16.34	17.19	17.4
DS1-4	26.74	14.9	15.38	15.12
DS2-1	15.8	16.78	16.18	17.23
DS2-2	15.25	17.93	17.45	19.83
DS2-3	14.88	12.88	15	18.4
DS2-4	14.86	19.81	14.94	17.02
DM1	16.8	14.4	16.56	19.12
DM2	12.1	14.97	16.47	19.52
DM3	14.97	16.58	16.52	18.13
DM4	13.87	14.38	17.73	18.46
Average	18.22	16.20	16.04	17.96
MS1-1	78.42	77.12	95.50	41.21

Treatment	Experiment 1 Spraying time (s)	Experiment 2 Spraying time (s)	Experiment 3 Spraying time (s)	Experiment 4 Spraying time (s)
MS1-2	75.15	78.34	94.25	40.45
MS1-3	79.34	75.45	95.25	41.62
MS1-4	78.20	76.12	93.34	42.3
MS2-1	130.25	131.24	75.42	52.1
MS2-2	131.40	130.40	76.32	53.33
MS2-3	129.54	133.65	78.12	53.12
MS2-4	132.33	132.17	74.21	50.43
MM1	89.25	84.24	81.12	34.5
MM2	91.22	85.13	80.23	32.12
MM3	88.35	82.24	82.41	32.45
MM4	89.12	80.25	85.45	35.2
Average	99.38	105.53	84.3	77.37

2.4 Data analysis

The number of individual insect pests and natural enemies, as well as the percentage of pest infestation and disease, was recorded by visual scoring using quadrat 25c m x 25 cm on the day before spraying and 6 to 7 days after spraying. The data collected were then analysed appropriately using the SAS 9.4 software. The data were statistically analysed using analysis of variance (ANOVA) and Duncan multiple range test to test the significance to separate the means at $p < 0.05$.

3. Results

3.1 Efficacy of Pesticide Application Using Drone on Controlling Number of Individual Insect Pest and Natural Enemies

The results had shown that there was no significant difference between manual and drone applications for the number of insect pests and natural enemies (Figure 4). However, the manual application has the lowest pests and natural enemies as compared with drone application. The number of insect pests was higher than natural enemies for both manual and drone applications.
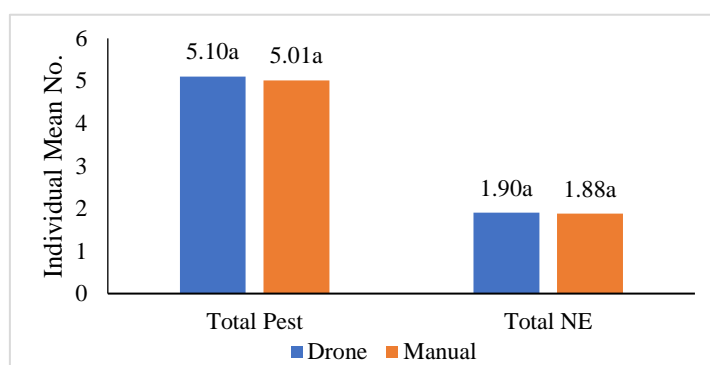
Figure 4. Total number of insect pest and natural enemies between manual and drone application.

Table 3. Correlation between type of application and type of pesticide use in this study.

	Total Insect Pest		Total Natural Enemies (NE)	
	Drone	**Manual**	**Drone**	**Manual**
Single	4.69a	4.69a	1.82a	2.03a
Mixture	4.13a	4.72a	2.41a	1.79a
Untreated	6.47a	5.63a	1.47a	1.82a
Mean	5.1	5.01	1.9	1.88
CV	57.95	49.69	66.99	65.32

The results from this study have also shown that there were no significant differences between untreated, single and mixture pesticides application (Table 3). Nevertheless, the number of insect pests was the highest for untreated compared with single and mixture pesticides. There was also no significant difference in the correlation between application type and type of pesticides used in this study. The drone application was more or less the same as the manual application regardless of whether we used single or mixture pesticide. It is important to note that the dosage of pesticides for a manual application is not the same as the dosage of pesticides for drone application and the recommended dosage on the pesticide label is for manual applications. The dosage that has been used in this study is as recommended dosage as on pesticide label whether it's the drone or manual application, which was similar to the current farmers' practice in Malaysia.

3.2. Efficacy of Fungicide Application Using Drone on Controlling Rice Diseases

Data on the disease incidence showed that there was no incidence of sheath blight recorded at the stage of maximum tillering and panicle initiation. The symptoms of sheath blight disease were observed at the booting stage and the incidence was considered low. Results shown in Table 4 indicated that there was no significant difference in disease

incidence in neither pesticide application techniques of using the drone sprayer nor knapsack motorised sprayer. This might be due to very low disease intensity occurring in the field.

Table 4. Mean square value for sheath blight incidence at maximum tillering to milky stage.

Source	DF	47DAS	54DAS	62DAS	70DAS	77DAS	84DAS	103DAS	112DAS	118DAS
Pesticide application technique	1	0.00	0.00	0.00	3.47	0.83	0.01	1.00	5.20	21.89
Pesticide mixture	2	0.00	0.00	0.00	2.37	0.94	3.44	0.15	1.28	7.60
Pesticide application technique X Pesticide mixture	2	0.00	0.00	0.00	1.22	0.86	2.98	2.57	9.36	4.63
Plot/Subplot	3	0.00	0.00	0.00	0.47	0.13	3.03	2.44	21.67	3.26
Pesticide application technique X Block	3	0.00	0.00	0.00	0.68	0.62	3.81	0.34	1.16	1.81

As for panicle blast, there was no significant difference in blast incidence on pesticide application technique (Table 5). Nevertheless, there was a significant difference of panicle blast incidence on pesticide mixture technique at 112 DAS and 118 DAS in drone and knapsack motorised sprayer, respectively; whereby single pesticide and tank mix pesticide application showed better disease control compared to untreated plot (Figure 5).

Table 5. Mean square value for panicle blast incidence at booting to dough ripe stage.

Source	DF	70DAS	77DAS	84DAS	90DAS	99DAS	103DAS	112DAS	118DAS
Pesticide application technique	1	0.00	0.00	0.00	0.00	11.72	10.60	1.49	0.48
Pesticide mixture	2	0.00	0.00	0.00	0.00	0.53	0.43	5.85*	24.94*
Pesticide application technique X Pesticide mixture	2	0.00	0.00	0.00	0.00	0.12	0.10	5.64*	10.42
Block	3	0.00	0.00	0.00	0.00	2.00	2.04	2.71	4.18

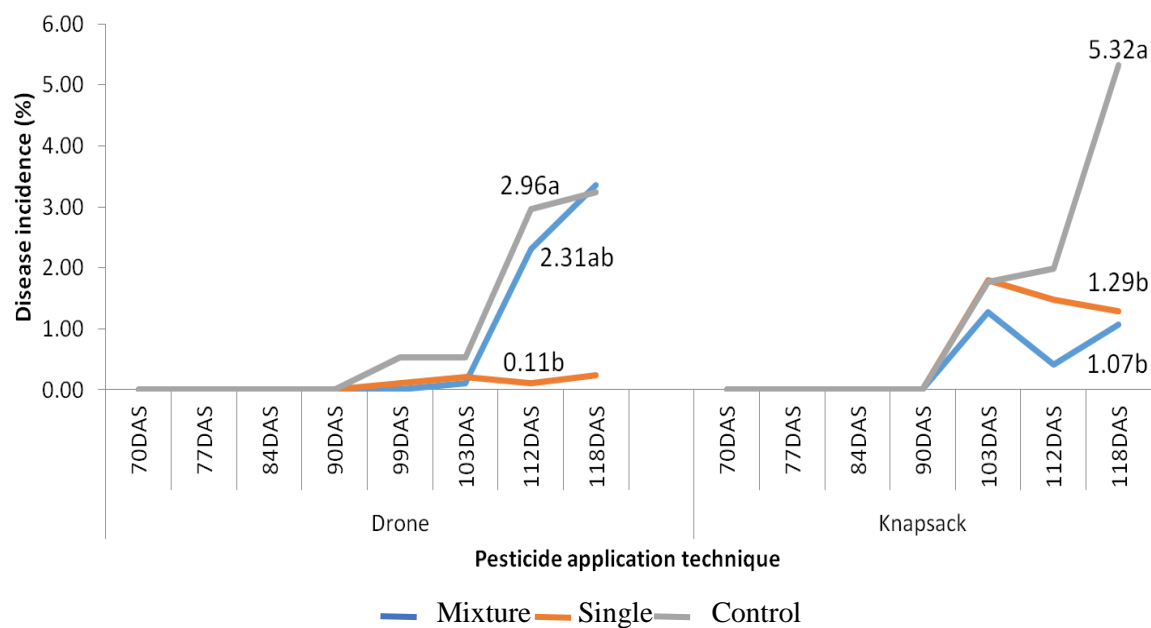|								
Pesticide application technique X Block	3	0.00	0.00	0.00	0.00	1.39	1.24	2.33	7.56

*Significant at *p<0.05*

Figure 5. Efficacy of pesticide application technique and pesticide mixture on panicle blast incidence.

4. Conclusions

In the current study, both knapsack and drone sprayers used different spraying rates but with the same chemical concentration. Results indicated that there was no significant difference in the efficacy of drone application and knapsack motorised sprayer in controlling insects, natural enemies and diseases such as sheath blight and panicle blast diseases. There are still no pesticides specifically for drone application in the Malaysian market. However, the drone sprayer required less time for spraying each plot compared to a manual application. Currently, the charges per hectare for drone spraying and knapsack spraying are the same which is RM 80/hectare. Therefore, Rice farmers have the option to choose what applications to use in their field to control insect pests and diseases. In this, they have to consider the cost, availability, field condition, hazardous etc. However, the experiment should be repeated due to very low disease intensity and severity encountered in this study and unfavourable weather conditions in this season.

Conflicts of Interest: The authors declare no conflict of interest.

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