International Journal of Agricultural Technology 2021Vol. 17(4):1561-1568
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Efficacy of the FAZER helicopter unmanned aerial vehicle (UAV) in controlling rice leaf folder and dirty panicle disease in paddy fields

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Punyawattoe, P., Sutjaritthammajariyangkun, W., Thirawut, S., Chaiyasing, N., Supornsin, S., Sampaothong, S. and Nagura, T. (2021). Efficacy of the FAZER helicopter unmanned aerial vehicle (UAV) in controlling rice leaf folder and dirty panicle disease in paddy fields. International Journal of Agricultural Technology 17(4):1561-1568.

Abstract The efficacy of the FAZER helicopter unmanned aerial vehicle (UAV) to control rice leaf folder and dirty panicle disease in paddy fields was investigated in Suphanburi province, Thailand. Four different application techniques were purposed as FAZERs at the rate of 8 and 16 L/ha and normal spray application using spray lance at the rate of 250 and 375 L/ha. The bio-efficacy of the spraying techniques in the first experiment was monitored rice leaf folder treated with flubendiamide + thiacloprid 24% + 24% W/V SC at a dose of 75 ml/ha at the booting stage. Subsequently, the effect of fungicide to control dirty panicle disease treated with tebuconazole + trifloxystrobin 50 % + 25 % WG was recorded by using a dose of 175 g/ha at the heading and flowering stages. The results indicated that a FAZER helicopter unmanned aerial vehicle (UAV) proved to be equally effective as the traditional spraying method to control leaf folder and dirty panicle disease. It is revealed that FAZER helicopter unmanned aerial vehicle (UAV) can be interesting for the alternative choice and enabled rational pesticide application for rice production in Thailand.

Keywords: FAZER helicopter UAV, Rice leaf folder, Dirty panicle disease

Introduction

Commercial rice production in Thailand suffers from the damaged diseases and infestation of insect pests. There are approximately 50 different species of pests and diseases have been attacked the rice crops in Thailand (Rice Department, 2019). Two such pests and disease are rice leaf folder and dirty panicle disease. Rice leaf folder (*Cnaphalocrocis medinalis* Guenée),

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Pyralidae Lepidoptera, have increased in abundance since the late 1980's and have become major problem in Thailand (Senthil *et al*., 2016). Leaf folder larvae invaded to the growing paddy on leaves longitudinally and voraciously fed on the green foliage, which resulted in papery dry leaves. Losses incurred are insurmountable yield losses can reach between 60-80% (Park *et al*., 2014). The panicle disease also damaged rice which caused by *Helminthosporium oryzae*, *Curvularia lunata* and *Fusarium moniliformae* leading to reduced seed quality and infected the plants before and after harvest (Thavong, 2002).

Typically, the rice growers have applied insecticides to control these insect pests at a high spray volume using a spray lance fitted with a motorized hydraulic knapsack sprayer by farmers in Thailand. However, these sprayers' ability is limited the uniform coverage throughout rice canopy and leading to be less control efficacy.

The problem has encountered on operator safety, cost of production, lack of labors, especially increasing cost of operating paddy fields become the important factors to improve the spray application techniques (Wechakit *et al*., 2009; Punyawattoe *et al.*, 2019a). In recent years, the new approach of aerial spraying by unmanned aerial vehicles (UAVs) has interestingly increased to improve the efficacy of application in many areas in Asia, including Korea China and Japan, where the most fields are small-scale (Xue *et al*., 2008; Lan *et al*. 2017). FAZER helicopter unmanned aerial vehicle (UAV) has been adopted as a research platform by many countries worldwide (Xue *et al*., 2013 and 2016; Qin *et al*., 2018). However, there is still lack the efficacy technique of UAVs in paddy fields in Thailand.

The major objective of this study was to optimize spraying techniques and recommend equipment to farmers using FAZER helicopter unmanned aerial vehicle (UAV), and to compare spray efficacy using UAVs and traditional spraying methods.

Materials and methods

Spray application technique

Four application techniques were selected for testing. The first application technique involved in a FAZER helicopter unmanned aerial vehicle (UAV) (Yamaha Corporation), with 2 fan-type nozzles installed (XR 110025, Spraying System Co., Ltd., USA), at a rate of either 8 or 16 L/ha, referred to as FAZER 1 and FAZER 2, respectively. The second application technique involved in a motorised hydraulic knapsack sprayer (Maruyama model MS 073D) with a tank capacity of 25 L (Maruyama Co. Ltd, Japan) and an attached spray lance at a rate of either 250 or 375 L/ha, as referred to as MK 1 and MK 2, respectively.

Field plot, experimental design and data collection

The field experiments were conducted in Suphanburi province on rice var. Pathumthani. The experiment was performed as a randomized completely block design (RCBD) with four replications. Treatments were four spray application techniques and untreated controls. The plots were 50 m long and 24 m wide. To avoid cross-contamination between plots, the sampling site was located 50 m from the edge of each treatment plot.

Rice leaf folder infestation

The rice leaf folder (*Cnaphalocrocis medinalis*) was observed and treated with flubendiamide + thiacloprid 24% + 24% SC at 75 ml/ha at the booting stage of 55 days after sowing when the attack of leaf folder reached 15% per plot. Each plot was sampled from 20 randomly selected hills before and after the application of insecticides. The percentage of infestation of folded leaves were recorded 7, 10 and 14 days after application (Entomology and Zoology Group, 2010).

The percentage of folded leaves was calculated using the following formula:

$$\text{Folded leaves (\%)} \ \frac{\text{No. of infested leaves (hills)}}{\text{No. of total leaves}} \times \frac{\text{No. of infested hills}}{\text{No. of hills in a sample area}} \times 100$$

Dirty panicle disease

The dirty panicle diseases which caused by *Helminthosporium oryzae, Curvularia lunata* and *Fusarium moniliformae* were observed and treated with tebuconazole + trifloxystrobin 50 % + 25 % WG at 175 g/ha at the heading and flowering stages (74 and 91 days after sowing). The data regarding the occurrence of dirty panicle diseases were collected from randomly in 8 m x 8 m plots after the symptom appeared. The number of infected panicles was measured (Plant Pathology Research Group, 2010).

Statistical analysis

Significant differences were determined using an analysis of variance (ANOVA) and Tukey's test at a significance level of 95% with SPSS v. 22.0 (SPSS, Inc., IBM, Chicago, IL, USA).

Results

Rice leaf folder infestation

Rice leaf folder infestation was recorded based on the percentage of folded leaves as shown in Tables 1 and 2. Before application, the mean numbers of folded leaves for all treatments were not significantly different. After application, all treatments were significantly less than the control. When comparing the efficacy among treatments, FAZER 1 and FAZER 2 at the rate of 8 and 16 L/ha, respectively were equally as effective as MK 1 and MK 2 in controlling the rice leaf folder at the rate of 250 and 375 L/ha (traditional method) with the same application rate (75 ml/ha) used in both field trials.

Table 1. Folded leaves (%) among spray application techniques when treated with flubendiamide + thiacloprid 24% + 24% W/V SC in Suphanburi province, July 2018 (1st trial)

Treatment	Spray volume L/ha	Application rate (ml/ha)	Folded leaves (%) [a/]			
			Before application	7 DAA [b/]	10 DAA	14 DAA
FAZER 1	8	75 ml	33.0	23.5^{b}	16.8^{b}	8.4^{b}
FAZER 2	16	75 ml	33.5	24.9^{b}	17.8^{b}	9.0^{b}
MK 1	250	75 ml	35.0	24.0^{b}	16.5^{b}	8.0^{b}
MK 2	375	75 ml	34.0	23.8^{b}	17.0^{b}	7.5^{b}
Untreated	-	-	37.8	40.0^{a}	41.5^{a}	47.2^{a}
CV (%)			23.31	22.55	22.12	25.78

[a/] Means within a column followed by the same letter or no letter are not significantly different at $p < 0.05$; Tukey's Test
[b/] Days After Application

Table 2. Folded leaves (%) among spray application techniques when treated with flubendiamide + thiacloprid 24% + 24% W/V SC in Suphanburi province, July 2018 (2nd trial)

Treatment	Spray volume L/ha	Application rate (ml/ha)	Folded leaves (%) [a/]			
			Before application	7 DAA [b/]	10 DAA	14 DAA
FAZER 1	8	75 ml	47.9	28.8^{b}	10.8^{b}	6.2^{b}
FAZER 2	16	75 ml	43.0	25.8^{b}	9.2^{b}	6.5^{b}
MK 1	250	75 ml	39.5	23.0^{b}	12.8^{b}	5.0^{b}
MK 2	375	75 ml	41.5	21.0^{b}	9.5^{b}	6.8^{b}
Untreated	-	-	44.2	45.4^{a}	40.5^{a}	42.0^{a}
CV (%)			25.39	33.86	39.43	48.92

[a/] Means within a column followed by the same letter or no letter are not significantly different at $p < 0.05$; Tukey's Test
[b/] Days After Application

Dirty panicle disease

The effective control of dirty panicle disease was measured using the percentage of pathogen incidence in seeds as shown in Tables 3 and 4. The percentage of pathogen incidence in all treatments was significantly less than the control with no significantly different effective control between FAZER 1 and FAZER 2 at the rate of 8 and 16 L/ha, and MK 1 and MK 2 at the rate of 250 and 375 L/ha (traditional method) with the same application rate (175 g/ha) used in both field trials.

Table 3 Effect of fungicides on dirty panicle disease among spray application techniques when treated with tebuconazole + trifloxystrobin 50 % + 25 % WG in Suphanburi province from August to September 2018 (1st trial)

Treatment	Spray volume L/ha	Application rate (g/ha)	% pathogen incidence [a/]
FAZER 1	8	175 g	8.3[a]
FAZER 2	16	175 g	8.8[a]
MK 1	250	175 g	7.0[a]
MK 2	375	175 g	7.3[a]
Untreated	-	-	27.5[b]
CV (%)			9.65

[a/] Means within a column followed by the same letter or no letter are not significantly different at $p < 0.05$; Tukey's Test

Table 4. Effect of fungicides on dirty panicle disease among spray application techniques when treated with tebuconazole + trifloxystrobin 50 % + 25 % WG in Suphanburi province from August to September 2018 (2nd trial)

Treatment	Spray volume L/ha	Application rate (g/ha)	% pathogen incidence [a/]
FAZER 1	8	175 g	17.3[a]
FAZER 2	16	175 g	17.0[a]
MK 1	250	175 g	18.5[a]
MK 2	375	175 g	16.5[a]
Untreated	-	-	34.8[b]
CV (%)			24.2

[a/] Means within a column followed by the same letter or no letter are not significantly different at $p < 0.05$; Tukey's Test

Discussion

In this study, the UAV of the FAZER provided similar efficacy in controlling rice pests. This agrees with the results of Wang *et al*. (2020) who found that the control efficacy of rice blast and the rice leaf roller for the UAV application was basically equal to or slightly worse than the backpack sprayer. Xue *et al*. (2013) studied the effect of the rice leaf roller control using UAV with chlorpyrifos at 40% SC and calculated that compared to traditional manual pesticide application, no significant difference in efficacy was found between the recommended pesticide dose (75 g/hm^2) and decreased dose of 20–30% with the same spraying volume at 10 d after UAV spraying. Punyawattoe *et al*. (2019a) studied the bio-efficacy of UAV spraying techniques with the fungicide tebuconazole + trifloxystrobin 50 + 25% WG on dirty panicle disease at a dose of 175 g/ha applied twice to rice at the heading and flowering stages in Suphanburi and Chainat Provinces. These trials revealed that the UAV was proven to be equally effective as the normal spray application method in controlling dirty panicle disease in rice.

This research examined the use of FAZERs for very low volume pesticide application against rice leaf folder and dirty panicle disease. The effect of normal spray application was used as the control, and the results reveal that spray volume is not necessarily a significant variable for rice leaf and panicle. Although MK 1 and MK 2 delivered 90% more spray volume than FAZER 1 and FAZER 2, they did not produce significantly more effectiveness, when operated at the lowest spray volume of 8 and 16 L/ha. Many researches also indicated that UAV spraying could enhance the duration of efficacy due to its low spray volume and highly concentrated spray pattern (Qin *et al*., 2016; Meng *et al*., 2018; Wang *et al.*, 2019a and 2019b). Regarding safety, operators traditionally apply pesticides by walking directly into the area being treated and, thus, are covered with spray solution along with the large and dense rice plants, contaminating the whole body (Punyawattoe, 2019b). Whereas operators employing the FAZER technique was able to apply the insecticide while remaining far away from the treated area (more than 20 m according to the standard procedure). Therefore, there is less risk of pesticide contamination to the operator than the traditional technique. At present, UAVs can provide an interesting alternative to solve the problem of the labor and water shortages involved with spraying. Furthermore, it can also improve accuracy and prevent the human error that can occur during application.

Acknowledgements

The authors would like to thank the Pesticide Application Research Section, Entomology and Zoology Group, Plant Protection Research & Development Office, Department of Agriculture, Thailand and Siam Yamaha Motor Robotics Co., Ltd. for supplying equipment for the field trials and technical support, making this research possible.

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(Received: 8 February 2021, accepted: 20 June 2021)