INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
21–0993/2022/27–5–315–320
DOI: 10.17957/IJAB/15.1932
http://www.fspublishers.org

Full Length Article

Field Evaluation of Boom Sprayers and Spray Lance for Controlling Melon Thrips Populations on Orchids

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Received 24 November 2021; Accepted 26 April 2022; Published 26 May 2022

Abstract

An innovative spray application is required to reduce spraying time, spray loss, quantity and cost of insecticide and environmental contamination in Thai orchid nurseries. A colorimetric method with a tartrazine dye tracer was used in this study to evaluate droplet deposition on orchid flowers and spray loss under the orchid bench. The bio-efficacy tests were performed against melon thrips by spraying spinetoram 12% SC (Exalt) insecticide in orchid nurseries using three different types of spray equipment: the conventional spray lance, vertical and self-propelled booms. The spray lance exhibited the highest droplet deposition, although its performance was not significantly different from the self-propelled and vertical booms. However, spray lance produced substantially more spray loss than the two other tested new boom sprayers. The means of thrips/inflorescence were on par with all tested sprayers at 3, 5 and 7 DAS. The untreated control group produced a higher population of thrips/inflorescence than the treated fields. The vertical and self-propelled booms were found to reduce spraying time (47.90 to 74.71%, respectively) and quantity of insecticide required in the orchid nursery (25.00 and 27.38%, respectively) than spray lance sprayer. When comparing the cost of insecticide, the self-propelled boom was the cheaper followed by the vertical boom and the spray lance as most expensive one. The reduction in cost of insecticide using vertical and self-propelled booms was 24.35 and 27.50%, respectively as compared to spray lance.

Keywords: Self-propelled boom sprayer; Vertical boom sprayer; Droplet deposition; Spray loss; Spray operational parameters

Introduction

As orchid pests, melon thrips (*Thrips palmi* Karny) in Thailand have a significant economic impact (Maketon *et al*. 2014). When no insecticide is applied, they attack over 74% of blooms, and being quarantined insects, prevent the export of infested orchids. The farmers must prevent the infestation of melon thrips on the plants to meet international phytosanitary standards and acceptance by the exporters and importers (MOAC 2009).

Insecticide spraying is the most popular method to keep melon thrips away from orchids because it is more convenient, faster, and easier to implement than other preventative methods. However, orchid growers in Thailand continue to face problems with spraying applications in the nursery, mainly due to a shortage of labour and increasing wages (Punyawattoe *et al*. 2016). With the traditional spray lance technique, Droplet deposition and uniformity in the orchid canopy is poor, and resulting in a lack of efficacy to control insect pests especially melon thrips. The nursery structure also makes it difficult to import the necessary mechanisation (Punyawattoe *et al*. 2019). In addition, the agricultural sector is raising concerns about the risk of operator exposure and contamination to the environment by agrochemicals. To address these issues, the Government of Thailand is establishing a project under the Plant Protection Research and Development Office, Department of Agriculture, to develop pesticide application technology in the orchid nursery. The objective of the project is to develop innovative spray equipment or spraying techniques for orchid growers. The expectations are to find very simple, cheap and suitable equipment for practical use in the field.

This research is also consistent with Thailand's policies on agricultural product quality and market competition. The main objectives of this study are to assess and compare the efficacy of boom sprayers as an innovative

To cite this paper: Punyawattoe P, S Sampaothong, N Chaiyasing, S Thirawut, W Sutjaritthammajariyangkun, S Supornsin (2022). Field evaluation of boom sprayers and spray lance for controlling melon thrips populations on orchids. *Intl J Agric Biol* 27:315–200

spray equipment and traditional spray lances in terms of droplet deposition, spray loss and controlling the melon thrips population on orchids including analysing the spraying time, amount and cost of insecticide. The data collected will form the basis of an innovative spray application to Thailand's precision plant protection system.

Materials and Methods

Experiment site

The field trials were conducted at a commercial Dendrobium orchid farm in Samphran District, Nakhonpathom Province, Thailand. The experiments were performed on orchids measuring 0.4 m in height from the orchid bench, plots of 20 m in length and 7 m in width, covering a total area of 140 m^2/ plot at a distance of 7 m from the edge of each plot to create a buffer zone and avoid cross-contamination between treatments (Fig. 1).

Spraying equipment and spray volume

Three different items of spraying equipment were designed for testing (Table 1). A conventional spray lance fitted with a traditional hollow cone nozzle had an orifice of 2.0 mm in diameter. This was attached to a high-pressure pump sprayer and applied with a pressure of 4 bar to deliver a spray volume of 1000 L/ha according to the farmer's practice.

The new vertical boom was fixed with a hose *via* an external pump and tank, consisting of three flat fans (TeeJet XR8004) with a nozzle spacing of 0.4 m installed at an offset angle of 10 degrees. The self-propelled boom consisted of six flat fan nozzles (TeeJet XR8004) with a nozzle spacing of 0.4 m. The spray pressure was set at 4 bar to deliver a spray volume of 750 L/ha which is the recommended rate.

Spraying swath width

The spray lance was covered a swath, 0.5 m wide on both sides of each orchid bench. The vertical boom was covered a swath one-metre-wide along one side of the orchid bench before being turned to spray the other bench. The self-propelled boom was covered a swath two metres wide along two sides of the orchid bench, and the operator moved the boom along every other row (Fig. 2).

Droplet deposition and spray loss

To evaluate droplet deposition and spray loss, a 1% solution of tartrazine ($C_{16}H_9N_4Na_3O_9S_2$) was sprayed. Orchid samples were collected from the plots, each containing 120 flowers. For spray loss evaluation, the samples were placed in petri dishes, five per row of orchids and kept in a UV-proof container. The samples were washed in 10 mL of distilled water and tested for optical density using a microplate reader, set to a 470 nm light.

The amount of tracer contained in the sample was calculated according to each target measurement. Correction factors like measurement range, dilution, and the volume of absorbent liquid were considered. The droplet deposition and spray loss results are provided in μL/flower and $\mu L/cm^2$, respectively.

Efficacy in the control of melon thrips

To evaluate the effectiveness of boom sprayers and spray lance against melon thrips, trials were conducted using four treatments, including untreated control from May to July 2019 (Table 2). To assess the bio-efficacy of spraying techniques, spinetoram 12% SC (Exalt) was sprayed at the recommended rate of 10 mL/20L of water. Prior to spraying, the density of melon thrips was assessed by collecting 20 randomly selected inflorescences per plot. Four melon thrips per inflorescence (economic threshold level) indicated the need for spraying (Srijuntra *et al.* 2019). Treatments were evaluated three, five and seven days after spraying (PPRD 2012).

Analysis of spraying time and cost of insecticide

Data on spraying time and the cost of insecticide were collected at three different time intervals between September to October 2019, covering an area of 1 Rai (0.16 ha) which is the official measurement unit in Thailand. The cost of insecticide was determined after spraying by weighing the quantity of insecticide used. The quantity of insecticide was converted into US dollars to compare the average product cost per area, using the prices charged by local agricultural chemical suppliers.

Statistical analysis

The experimental layout for the three treatments consisted of the Randomized Complete Block Design. Seven replications were used for spray deposition and spray loss. Four treatments with five replications were used to assess the efficacy of the experiments on melon thrips. The means of total spray deposition, spray loss and melon thrips population were compared using analysis of variance (ANOVA) and Tukey's test with SPSS v. 22.0 software (SPSS, Inc., IBM, Chicago, IL, USA).

Results

Droplet deposition and spray loss

The spray lance at 1.40 μL/flower exhibited the highest droplet disposition, followed by the self-propelled boom, and vertical boom at 1.32 and 1.14 μL/flower, respectively. However, they were not significantly different, although the

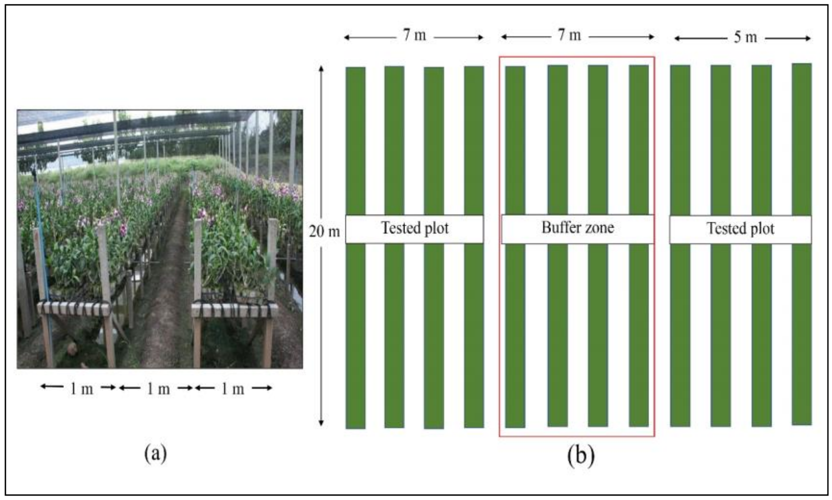

Fig. 1: Experimental layout: (**a**) spacing of orchid benches in the orchid nursery and (**b**) field plot layout for testing the plot and buffer zone

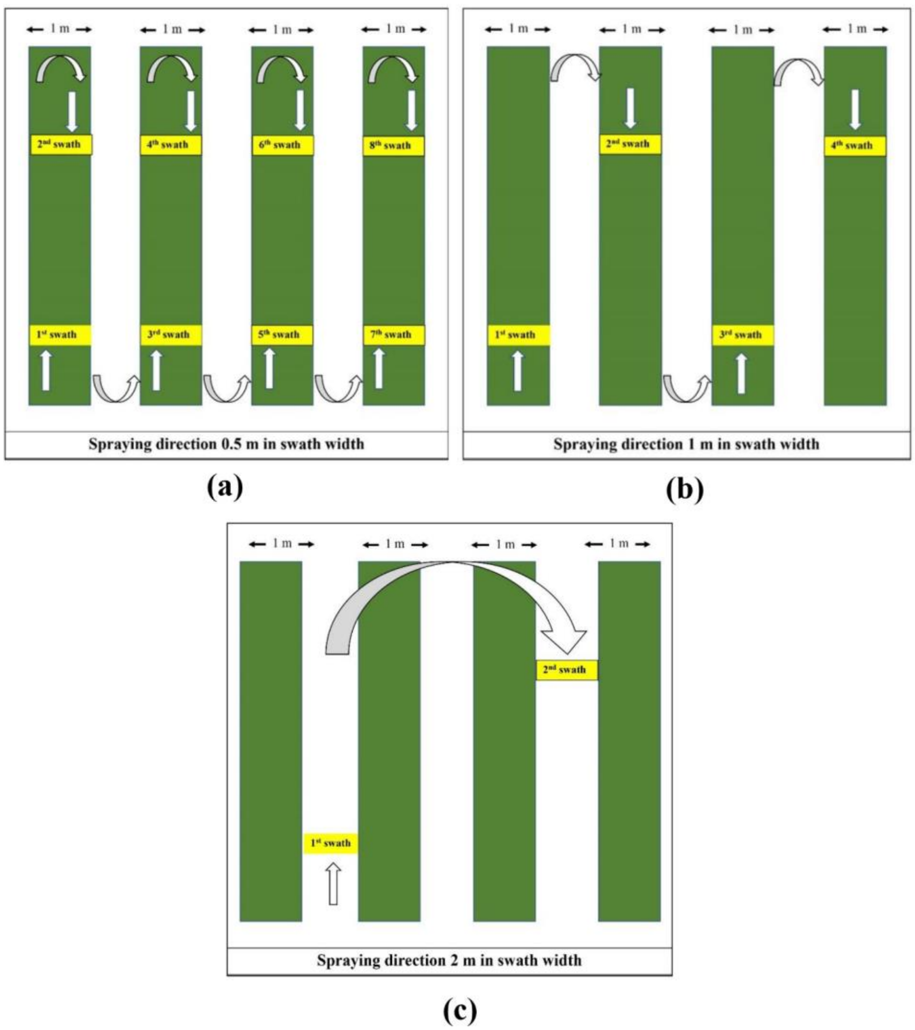

Fig. 2: Swath spraying width: (**a**) a 0.5-metre-wide swath using the spray lance; (**b**) a one-meter-wide swath using the vertical boom and (**c**) a two-meter-wide swath using the self-propelled boom

Table 1: Details of application parameters for spraying techniques in the experiments

Treatment	Nozzle type	Number of nozzles	Flow rate (L/min)[a/]	Spray volume (L/ha)	Swath width (m)	Number of swath per tested plot
Spray lance	Hollow cone nozzle Ø 2.0 mm	1	4	1,000	0.5	8
Vertical boom	Fan XR8004	3	5.7	750	1.0	4
Self-propelled boom	Fan XR8004	6	11.4	750	2.0	2

[a/] At spray pressure of 4 bar

Table 2: Details of treatment on the bio-efficacy test

Treatment	Spray volume (L/ha)	Insecticide	Recommendation rate mL/20 L of water
Spray lance	1,000	Spinetoram 12% SC	10
Vertical boom	750	(Exalt)	10
Self-propelled boom	750		10
Untreated control	-	-	-

Table 3: Means of droplet deposition and spray losses among spray application techniques at Samphran district, Nakhonpathom Province, Thailand during May, 2019

Treatment	Spray volume (L/ha)	Droplet deposition on orchid flower (μL/flower)	Spray losses to the ground (μL/cm^2)
Spray lance	1,000	1.40	0.47 a
Vertical boom	750	1.14	0.34 b
Self-propelled boom	750	1.32	0.33 b

According to Tukey's Honest Significant Difference (HSD) at $P \leq 0.05$ means in the same column followed by the same letter are not significantly different

Table 4: Efficacy of spinetoram (Exalt 12 % SC) for controlling melon thrips; *Thrips palmi Karny* with different spray application techniques at Samphran district, Nakhonpathom Province, Thailand, during May 2019 (1st trial)

Treatment	Spray volume (L/ha)	Insecticide usage (mL/ha)	Means of thrips/inflorescences			
			Before spraying	3 DAS[a/]	5 DAS	7 DAS
Spray lance	1,000	500	4.13	0.45 b	0.48 b	0.35 b
Vertical boom	750	375	4.28	0.50 b	0.43 b	0.33 b
Self-propelled boom	750	375	4.15	0.35 b	0.28 b	0.25 b
Untreated control	-	-	4.30	3.88 a	4.18 a	4.23 a

[a/]DAS = Day after spraying: According to Tukey's Honest Significant Difference (HSD) at $P \leq 0.05$ means in the same column followed by the same letter are not significantly different

Table 5: Efficacy of spinetoram (Exalt 12 % SC) for controlling melon thrips; *Thrips palmi* Karny with different spray application techniques at Samphran district, Nakhonpathom Province, Thailand, during July 2019 (2nd Trial)

Treatment	Spray volume (L/ha)	Insecticide usage (mL/ha)	Means of thrips/inflorescences			
			Before spraying	3 DAS[a/]	5 DAS	7 DAS
Spray lance	1,000	500	4.93	0.53 b	0.52 b	0.32 b
Vertical boom	750	375	4.85	0.63 b	0.40 b	0.35 b
Self-propelled boom	750	375	4.88	0.48 b	0.38 b	0.25 b
Untreated control	-	-	5.00	4.28 a	3.89 a	3.95 a

[a/]DAS = Day after spraying: According to Tukey's Honest Significant Difference (HSD) at $P \leq 0.05$ means in the same column followed by the same letter are not significantly different

spray lance delivered 33% more spray volume than the new spray booms. It was evident from the observed data that the spray lance produced the highest spray loss at 0.47 μL/cm^2, which was significantly more than the self-propelled and vertical booms, which exhibited spray losses of 0.34 and 0.33 μL/cm^2, respectively (Table 3).

Efficacy of melon thrips

The recorded melon thrips infestation was based on the number of melon thrips/inflorescence (Table 4–5).

The first trial

Although the spray lance delivered 33% more volume than the new spray boom, none of the applications was found to be significantly effective in the reduction of melon thrips population at the 5% level of significance. The melon thrips population varied from 0.35–0.50, 0.28–0.48 and 0.25–0.35 thrips/inflorescences at 3 DAS, 5 DAS and 7 DAS, respectively. The means of melon thrips after all spray applications were not significantly different from each other (Table 4).

The second trial

Similar trends were observed at 3 DAS, 5 DAS and 7 DAS for the spray lance, vertical boom and self-propelled boom, none of which were significantly effective in the reduction of the melon thrips population at the 5% level of

Table 6: Summary of means of spraying time in minutes, amount and cost of insecticide

Parameters	Spraying equipment		
	Spray lance	Vertical boom	Self-propelled boom
1. Spraying time (min: sec)			
1st spraying	41:24	22:16	9:33
2nd spraying	42:18	21:38	11:06
3rd spraying	40:42	20:54	10:48
Means	41:28	21:36	10:29
Decreasing spraying time vs spray lance (%)	-	47.90%	74.71%
2. Quantity of insecticide (mL/0.16 ha)			
1st spraying	83	64	55
2nd spraying	85	62	64
3rd spraying	82	60	62
Means	83.33	63	60.33
Decreasing quantity of insecticide vs spray lance	-	25.00%	27.38%
3. Cost of insecticide (US dollar/0.16 ha) [a/]			
1st spraying	3.48	2.68	2.30
2nd spraying	3.56	2.60	2.68
3rd spraying	3.44	2.51	2.60
Means	3.49	2.64	2.53
Decreasing cost of insecticide vs spray lance	-	24.35%	27.50%

[a/] 1 US dollar = 31.03 Thai Baht and Spinetoram package 250 mL = 41.89 US dollar (1,300 Thai Baht)

significance. The melon thrips population varied from 0.48–0.63, 0.38–0.52 and 0.25–0.35 thrips/inflorescences at 3 DAS, 5 DAS and 7 DAS, respectively. Moreover, all spray applications in both fields were found to be better in comparison to the untreated control group.

Analysis of spraying time and amount and cost of insecticide

It is evident that the spraying time of the spray lance was the slowest on average at 41:28 min/0.16 ha. Use of the vertical and the self-propelled booms was found to reduce the spraying time by approximately 20 to 30 min or 47.90 to 74.71% of time consumption.

The vertical and self-propelled booms were able to reduce the amount of insecticide usage in the orchid nursery by 25 and 27.38%, respectively (Table 6). When comparing the cost of insecticide, the self-propelled boom was the cheapest, followed by the vertical boom, with the spray lance being the most expensive. The vertical and self-propelled booms were found to reduce the cost of insecticide by 24.35 and 27.50%, respectively (Table 6).

Discussion

The droplet deposition and effectiveness of the vertical and self-propelled booms in controlling the melon thrips population were not significantly different, although the spray lance delivered a higher spray volume. The results suggest that since the droplets produced by the two boom sprayers were uniform, they could penetrate the orchid flower equally. Furthermore, the boom sprayer has a high-quality nozzle, enabling it to provide smaller droplets for better coverage inside the inflorescences. The spray can therefore be transported through the air more easily, as demonstrated by Sánchez-Hermosilla *et al.* (2011), Balsari *et al.* (2012). When operating the spray lance, the effectiveness of the process also depends on the skill of the worker involved. In contrast, when operating the boom sprayers, the workers merely need to hold or maintain the boom level over the target area (Nuyttens *et al.* 2009; Braekman *et al.* 2010). Consequently, boom spraying, and lance spraying were equally good when using the same volume of spray or less.

The results indicated trend similar to previous studies, where high-volume spraying leads to greater spray loss. A higher spray volume tends to result in more insecticide landing on ground inside the field in comparison to when less spray is used (Braekman *et al.* 2009; Sánchez-Hermosilla *et al.* 2012; Rincón *et al.* 2017; Failla and Romano 2020).

The results of our experiments indicated that the boom sprayer offers a new innovative alternative to the current technique used in Thailand's orchid nurseries since it has the potential to provide a better droplet deposition. Furthermore, it is less time-consuming and may reduce insecticide usage and spraying cost.

Conclusion

The boom sprayer is an innovative application technique for reducing spray time, spray loss, quantity and cost of insecticide to control the field population of melon thrips. Boom sprayers offer an efficient alternative to lance sprayer and may help to mitigate issues relating to the lack of manpower and increasing cost of imported spray equipment. Further studies are required to identify the effects of vertical nozzle spacing and distance to crop on the spray deposition to improve the spray efficacy in an orchid nursery.

Acknowledgements

The researchers would like to thank the staff from the Pesticide Application Research Section, Entomology and

Zoology Group, Plant Protection Research and Development Office, Department of Agriculture, Thailand, for their invaluable assistance in this research.

Author Contributions

Punyawattoe P and Sampaothong S conceptualised part of the research, performed the experiments, data collection, analysis and compiling and editing the manuscript. Sutjaritthammajariyangkun W, Thirawut S, Chaiyasing N, and Supornsin S performed the experiments and were involved in data collection.

Conflict of Interest

All authors declare no conflict of interest

Data Availability

Data presented in this study will be available on a fair request to the corresponding author.

Ethics Approval

Not applicable to this paper.

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