Operator exposure to spray deposits using various application techniques in paddy fields

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Abstract

Purpose – The safety of operators handling pesticides is still one of the main problems facing Thai agricultural workers. The purpose of this paper is to study the safety of farmers and the techniques recommended to farmers by the Department of Agriculture in Thailand, i.e. spraying to achieve optimum spray volume with consideration for wind direction – henceforth referred to as officer techniques.

Design/methodology/approach – Operator exposure was detected by verifying the deposition of dye tracer on the coveralls worn by ten spray service team leaders, for all applications between May and June 2017. For each technique, a total of 15 patches were attached at the lower legs, thigh, chest, forearms, upper arms, hands, face, forehead and back. Each individual technique was performed four times in the area of 1,800 m².

Findings – The results showed that the deposits with the farmers’ techniques was much higher than with officers’ techniques ranging from 2.32 to 23.91 times at the tillering stage and 9.90 to 56.79 times at the booting stage, respectively. These results indicate that the spray application technique has a considerable potential for reducing the contamination of spray operators by 56.96–98.23 percent. Operator safety can be considerably improved by the spray application technique employed. Without any investment and changing equipment, only by considering wind direction, officers’ techniques could avoid much deposition, which is the most practical operation in the field. The boom sprayer as a novel recommended technique is an alternative giving a positive result and it can be a substitute for the conventional method. Furthermore, the authors must pay attention to personal protective equipment (PPE) because depositions were discovered on the whole of the bodies of those tested. PPE is the best way to protect an operator from pesticide contamination.

Originality/value – Operator exposure data can be helpful in further development of exposure models and databases for risk assessment and pesticide registration in Thailand.

Keywords Agriculture, Operator exposure, Spray application techniques

Paper type Research paper

Introduction

Pesticide exposure is one of the most significant occupational risks among farmers in Thailand[1, 2]. The need to use large amounts of pesticides has impacted on human health and environmental concerns. The trend of reported cases of pesticide poisonings from 2010 to 2017 had dramatically increased[3]. These figures show there is a need for site-specific occupational hygiene advice. Estimates of operator exposure have been reported for several classes of pesticide and for diverse types of application equipment[2, 4, 5]. The main point of these studies indicates that dermal exposure is the foremost route of exposure for pesticide
applicators, irrespective of the type of spray application[6, 7]. Other researchers have observed an important non-uniformity of dermal exposure from different kinds of spray application techniques and spray volumes[8–10]. In Thailand, the use of spraying technique operated by farmers creates the highest exposure risk for the operator, especially compared with the official techniques recommended by the Department of Agriculture (DOA), Thailand, where it is suggested that the operator should be well protected and should spray with due regard to optimum spray volume and wind direction. However, with farmers, the operator walks into the area that is being treated and can be covered with a spray solution, particularly when treating a large and dense canopy[8, 10–13]. To improve knowledge about and increase awareness of safe use and proper application techniques to reduce negative health impacts, the right pesticide application technique needs to be demonstrated to all spray service providers who are at high risk from pesticide exposure. To optimize the spraying techniques and recommend equipment to spray service providers, it is very important to demonstrate the importance of safe techniques through the evaluation of field trials. Moreover, operator exposure data can help further develop exposure models and databases for risk assessment and pesticide registration in Thailand. The main objective of this study is to compare the potential dermal exposure (PDE) of various parts of the body between officers’ techniques and farmers’ techniques under working conditions when spraying rice at different growth stages. This PDE provides vital information on the quantity of a plant protection product that contaminates uncovered body regions and clothing worn by the operator. This study can help to inform and develop a spray service provider network to provide knowledge of occupational health and safety to farmers in Thailand. Moreover, this study used an accepted method to determine the PDE of operators under field conditions, according to OECD guidelines[14].

Methods

Study area and study population

The study area was conducted in the Sri Prachan District, Suphanburi Province, and the study population was comprised of all ten team leaders of a spray service provider in this area. The participants were males, with an average age of 34.8 years. The participants were an average weight of 62.3 kg and an average height of 167.8 cm. Most participants had more than 9.6 years of spraying experience.

Spray application techniques

The reference equipment for spray application was a spray lance length of 0.7 m with an adjustable hollow cone type nozzle, which was connected to a motorized hydraulic knapsack sprayer (MK) with a tank capacity of 25 L. With this equipment, two application techniques were tested, herein referred to as MK (farmer) and MK (officer).

A motorized mist blower sprayer (MB) with a tank capacity of 12 L was also tested. With this equipment, two types of nozzle were evaluated. An air delivery hose length of 0.5 m was installed with an air shear nozzle and a rotary nozzle, herein referred to as MB (farmer) and MB (officer).

The two horizontal boom sprayers used in this test were connected to an MK sprayer as well as a spray lance. Each boom sprayer was an aluminum frame 6 m in width installed with 13 nozzles at a spacing of 0.5 m. The first one was fitted with a fan type nozzle, whilst another was installed with a cone type nozzle. With these techniques, the spray volume as well as MK (officer) was tested, herein referred to as Boom fan and Boom cone respectively. In all the tests, the working pressure was maintained at a constant 5 bar from pressure gauge, while the walking speed of the sprayer was varied according to the flow rate of the nozzle (Table I).
| Treatments    | Nozzle types                          | Flow rate per nozzle (L min\(^{-1}\)) | Flow rate all nozzles (L min\(^{-1}\)) | Swath width | Walking speed (m min\(^{-1}\)) | Real application rate (L ha\(^{-1}\)) | Operation time (min) | VMD |
|--------------|---------------------------------------|----------------------------------------|----------------------------------------|-------------|-------------------------------|---------------------------------------|---------------------|-----|
| MK (farmer)  | Adjustable cone Ø 2 mm                | 4.10                                   | 4.10                                   | 5           | 21\(^a\) (19)\(^b\)          | 387\(^a\) (425)\(^b\)                  | 16\(^a\) (17)\(^b\) | 240 |
| MK (officer) | Adjustable cone Ø 1 mm                | 2.10                                   | 2.10                                   | 4           | 14 (13)                        | 389 (430)                            | 28 (30)             | 205 |
| MB (farmer)  | Air shear nozzle                       | 2.08                                   | 2.08                                   | 6           | 20 (17)                        | 169 (195)                            | 13 (16)             | 150 |
| MB (officer) | Rotary nozzle (Wizza)                  | 0.85                                   | 0.85                                   | 4           | 13 (11)                        | 163 (193)                            | 29 (36)             | 120 |
| Boom fan     | XR 11001 VS                            | 0.48                                   | 6.24                                   | 6           | 27 (23)                        | 385 (454)                            | 11 (13)             | 170 |
| Boom cone    | 1299-08 Lilac                          | 0.38                                   | 4.94                                   | 6           | 21 (18)                        | 380 (449)                            | 14 (16)             | 160 |

**Notes:**
\(^a\) The values on rice at the tillering stage;
\(^b\) the values on rice at the booting stage
The spray direction was divided into three techniques. With techniques MK and MB (officer), the operator sprayed by advancing forward, moving the nozzle and spray lance or air delivered hose up and down over the rice row in a downwind direction from the outermost part of the rice canopy 0.5 m. With techniques MK and MB (farmer), the operator sprayed by advancing forwards and the spray lance or air delivery hose was moved from left to right over both sides of rice canopy. For the last technique with two boom sprayers, two operators walked in the same direction as the wind and the horizontal distance from the rice canopy was 0.5 m. Each individual technique was performed four times.

Field plots and crop condition during performance
Each plot of paddy field was 60 m long and 30 m wide. A 6 m drive row was cut out of the fields between each plot. The Pathumthani 80 rice variety was planned for this experiment and rice was maintained using standard cultural recommended practice.

Field trials were made when the rice reached tillering and booting stage at 35 and 65 days after sowing as these are the two stages where rice is most susceptible to insect pests and diseases. The plant usually needs an application of pesticides as well as representing two different growth stages of rice.

Method for detection of operator exposure
The colorimetric method, using tracer dye, helped determine operator exposure. Tartrazine was chosen for the present experiment because it combined high accuracy, safety and sensitivity with a significant reduction in time and cost. In addition, it is water soluble, stable under various light and temperature conditions and can be extracted easily from cellulose[15, 16]. Spray operator exposures were compared among the different spray application techniques by measuring the deposits of dye tracer spray liquids on patches (10 cm × 10 cm) fixed onto the spray operators’ garments. A total of 15 patches were attached at the lower legs, thigh, chest, forearms, upper arms, hands, face, forehead and back. The applications were run every other time to obtain approximately similar meteorological conditions each day during the period between May and June 2017.

In all of the experiments, the dye was used at the rate of 3.75 kg ha⁻¹. The samples were analyzed with a colorimeter (Jenway model 6051, Spectronic CamSpec Ltd, UK.) to match the specific absorption at a wavelength of 470 nm. After completing spraying an area of 1,800 m², the patches were removed carefully with clean forceps and each position was placed in a ziplock bag and labeled. Patches were spiked in the laboratory with a standard calibration solution of 1 to 0.0078125 percent. In spite of the high stability of Tartrazine, the samples were stored and transported under cool and dark conditions, and then analyzed as soon as possible. The tracer was rinsed off of the patches with 10 ml demineralized water in disposable Petri dishes. For sample analysis, the colorimeter was rinsed in a micro plastic cuvette with a capacity of 3 ml. The readings were given in µg L⁻¹. The amount of tracer contained in the sample, and thus the degree of potential dermal contamination, was calculated for each measurement position. An allowance was made for various correction factors, such as measurement range, dilution and the volume of the absorbent liquid. Statistical analysis was conducted for all the estimated measurements of treatments and subsequently compared with the farmer’s technique values by Student t-test. The results of the dye deposits were expressed in µg cm⁻² for a patch taken from each section of the operator’s body.

Ethical consideration
This study was approved by the research committee of the Plant Protection Research and Development Office, DOA, on April 19, 2017.
Results
The deposition of dye tracer on each body part through different spray application techniques in the two rice growth stages was referred to \( \mu g \ cm^{-2} \), as shown in Tables II and III. The results of statistical analysis for the difference among treatments by using Student \( t \)-test are presented in Table IV. The findings are that significant differences occurred on total deposition on operator exposure varied with application techniques. The operator exposure with the MK (farmer) was the highest, which is significantly higher than with all other techniques at tillering and booting stages. The operator of MB (farmer) received the second highest dosage deposit, which was only significantly different when compared statistically with MB (officer) at the tillering stage. However, the deposition was significantly higher than with all other techniques at the booting stage. The total deposition with both farmer’s techniques was found much higher than those with their corresponding officer’s techniques, which was up to 2.32–6.66 and 8.33–23.91 times at the rice tillering stage, and up to 9.91–17.25 times and 32.64–56.79 times at the booting stage.

Discussion
At the rice tillering stage, the differences in the total amount of dye deposition on the operator could be attributed to the spray direction. With both farmers’ techniques, operators performed the spray direction by directly walking into the area being treated and consequently were covered with spray solution. Together with the large and dense rice plants, contamination could be found on the whole body. Even if the spray volume from MB (farmer) was equal or less than double compared to those treatments of officers’ techniques, the dye deposits could be detected 2.33 to 6.66 times on the body. Similar studies[8,10,11] observed the contaminated surface could be found on the whole body when operators sprayed insecticides in front of them and walked through the sprayed crop plants. Operators employing the officers’ techniques performed by spraying in a downwind direction and not directly walking into the treated area were exposed to less deposition of dye tracer. It was found that some positions on the upper body such as on the face, the forehead and the back had quite a few deposits that could not be detected by the colorimeter.

With regards to MB (officer) sprayed by using a spray volume of 163–193 L ha\(^{-1}\), which was less than 2.33 times compared to other officer techniques, it was found that this sprayer generated the highest proportion of small droplets (Table I) when sprayed in the correcting wind direction. Furthermore, the contamination was less compared to those treatments of officers’ techniques.

MK (officer) is a technique comparable with two boom sprayers. However, the total deposition with MK (officer) was less than 1.59–1.90 times that with boom sprayers at the same application rate. The main reason was the difference in length between the spray lance of MK (officer) (0.7 m) and the boom handle (0.5 m), together with the position of the operator’s arms during the task. The arms operating the spray lance of MK (officer) was situated in front of the operator, whilst the boom sprayer was held at the side of the body. Furthermore, the handles of boom sprayers were not wide enough for swath width, which, on the fan type nozzle, covers 0.9–1 m, and a hollow cone type nozzle 0.6–0.8 m. These should be the reasons for the deposition difference between MK (officer) and boom sprayers, as also described by Sutherland et al.[17].

In the case of the two boom sprayers, the fan type nozzle deposited a little more than the hollow cone type nozzle. The fan type nozzle can generate a higher proportion of large droplets and give better penetration through the rice canopy. Thus, the dye deposition in the bottom of the rice canopy was higher when the fan type nozzle was used, which increased some deposition on the lower parts of the operator.

A similar result was observed at the rice booting stage, the highest deposition was still detected from farmers’ techniques. Additionally, this experiment indicated that the rice growth stage also influences deposition patterns. The depositions from MK and MB...
### Table II.
The deposition of dye tracer detected from cellulose patches: mean and standard derivations expressed as µg cm$^{-2}$ on different spray application techniques (on rice at the tillering stage)

| Patches’ positions | Sides | MK (farmer) | Mean ± SD | MK (officer) | Mean ± SD | MB (farmer) | Mean ± SD | MB (officer) | Mean ± SD | Boom fan$^a$ | Mean ± SD | Boom cone$^a$ | Mean ± SD |
|--------------------|-------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|------------|-----------|------------|-----------|
| Lower leg          | Right | 12.35       | 16.96     | 1.64        | 0.56      | 9.17        | 0.49      | 0.26        | 0.05      | 3.74       | 1.22      | 2.19       | 1.69      |
|                    | Left  | 12.3       | 9.13      | 1.37        | 0.41      | 9.05        | 0.66      | 0.20        | 0.04      | 1.55       | 1.22      | 2.66       | 1.62      |
| Thigh              | Right | 23.00       | 12.78     | 0.6         | 0.11      | 2.86        | 0.04      | 0.79        | 0.07      | 2.68       | 3.77      | 1.01       | 0.88      |
|                    | Left  | 18.53       | 2.69      | 0.61        | 0.24      | 2.81        | 0.08      | 0.68        | 0.04      | 2.75       | 1.18      | 1.98       | 1.46      |
| Chest              | Right | 4.25        | 3.39      | 0.45        | 0.05      | 0.39        | 0.08      | 0.27        | 0.04      | 0.2        | 0.06      | 0.14       | 0.03      |
|                    | Left  | 5.49        | 4.84      | 0.28        | 0.04      | 1.05        | 0.13      | 0.12        | 0.03      | 0.15       | 0.02      | 0.21       | 0.04      |
| Forearm            | Right | 8.71        | 8.53      | 0.67        | 0.46      | 1.37        | 0.25      | 0.79        | 0.07      | 0.72       | 0.5      | 1.21       | 1.53      |
|                    | Left  | 7.56        | 5.46      | 0.28        | 0.17      | 1.34        | 0.28      | 0.43        | 0.11      | 0.37       | 0.3      | 0.84       | 0.91      |
| Upper arm          | Right | 0.88        | 0.42      | 0.25        | 0.17      | 0.28        | 0.04      | 0.27        | 0.14      | 0.24       | 0.05      | 0.18       | 0.07      |
|                    | Left  | 0.39        | 0.07      | 0.19        | 0.1       | 0.35        | 0.08      | 0.2         | 0.1       | 0.16       | 0.07      | 0.12       | 0.03      |
| Hand               | Right | 1.19        | 0.33      | 0.28        | 0.04      | 0.46        | 0.07      | 0.27        | 0.04      | 0.25       | 0.08      | 0.23       | 0.07      |
|                    | Left  | 1.24        | 0.47      | 0.25        | 0.05      | 0.43        | 0.12      | 0.24        | 0.04      | 0.33       | 0.2      | 0.21       | 0.1      |
| Face               |       | 10.62       | 1.41      | ND$^b$      | –         | 0.27        | 0.06      | ND          | –         | ND         | –         | ND         | –         |
| Forehead           |       | 2.34        | 1.55      | ND          | –         | 0.12        | 0.03      | ND          | –         | ND         | –         | ND         | –         |
| Back               |       | 0.65        | 0.23      | ND          | –         | 0.58        | 0.14      | ND          | –         | ND         | –         | ND         | –         |
| Total              |       | 109.51      | 14.44     | 6.86        | 0.36      | 30.53       | 1.64      | 4.58        | 0.51      | 13.14      | 2.41      | 10.97      | 1.25      |

**Notes:** $^a$The amount of dye tracer on cellulose patches from two operators; $^b$ND: the amount of dye tracer from cellulose patches have quite a few deposits that cannot be detected by a colorimeter.
| Patches’ positions | Sides | MK (farmer) | Mean ± SD | MK (officer) | Mean ± SD | MB (farmer) | Mean ± SD | MB (officer) | Mean ± SD | Boom fan<sup>a</sup> | Mean ± SD | Boom cone<sup>a</sup> | Mean ± SD |
|--------------------|-------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|----------------|-----------|----------------|-----------|
|                    |       |             |           |             |           |             |           |             |           |                |           |                |           |
| Lower leg          | Right | 22.47       | 17.2      | 0.48        | 0.04      | 1.27        | 0.03      | 0.27        | 0.05      | 1.77           | 2.22      | 1.35           | 1.02      |
|                    | Left  | 21.83       | 17.81     | 0.64        | 0.32      | 1.45        | 0.12      | 0.22        | 0.07      | 1.98           | 2.11      | 1.25           | 1.08      |
| Thigh              | Right | 61.04       | 14.71     | 0.31        | 0.19      | 1.06        | 0.81      | 0.24        | 0.05      | 0.46           | 0.53      | 0.81           | 0.68      |
|                    | Left  | 48.97       | 44.16     | 0.45        | 0.15      | 4.61        | 0.35      | 0.18        | 0.03      | 1.34           | 0.91      | 0.6            | 0.79      |
| Chest              | Right | 3.81        | 0.48      | 0.46        | 0.03      | 4.12        | 0.53      | 0.69        | 0.04      | 0.76           | 0.55      | 0.2            | 0.08      |
|                    | Left  | 4.51        | 2.15      | 0.6         | 0.31      | 3.21        | 0.09      | 0.53        | 0.08      | 0.53           | 0.06      | 0.16           | 0.11      |
| Forearm            | Right | 19.68       | 4.79      | 0.76        | 0.28      | 0.48        | 0.03      | 0.18        | 0.03      | 0.42           | 0.25      | 0.75           | 0.91      |
|                    | Left  | 9.8         | 5.1       | 0.4         | 0.04      | 2.72        | 0.17      | 0.47        | 0.06      | 0.14           | 0.03      | 0.88           | 0.82      |
| Upper arm          | Right | 1.27        | 0.72      | 0.16        | 0.06      | 7.64        | 5.86      | 0.48        | 0.08      | 0.12           | 0.03      | 0.14           | 0.03      |
|                    | Left  | 8.3         | 7.27      | 0.16        | 0.06      | 6.52        | 0.61      | 0.37        | 0.07      | 0.17           | 0.12      | 0.14           | 0.06      |
| Hand               | Right | 2.13        | 0.28      | 0.22        | 0.07      | 16.25       | 5.77      | 0.8         | 0.08      | 0.12           | 0.03      | 0.11           | 0.02      |
|                    | Left  | 21.33       | 17.67     | 0.21        | 0.09      | 16.54       | 5.29      | 0.53        | 0.08      | 0.33           | 0.2       | 0.18           | 0.03      |
| Face               |       | 12.86       | 10.55     | 0.2         | 0.1       | 12.83       | 1.58      | 0.11        | 0.02      | 0.12           | 0.03      | 0.13           | 0.03      |
| Forehead           |       | 33.8        | 21.8      | ND<sup>b</sup> |          | 3.3         | 2.46      | ND          |          | 0.11           | 0.02      | 0.12           | 0.03      |
| Back               |       | 0.82        | 0.1       | ND          |          | 0.73        | 0.04      | ND          |          | ND             |          | ND             |          |
| Total              |       | 272.61      | 25.68     | 5.05        | 0.69      | 82.82       | 12.01     | 4.8         | 0.43      | 8.36           | 1.7       | 6.82           | 1.63      |

Notes: <sup>a</sup>The amount of dye tracer on cellulose patches from two operators; <sup>b</sup>ND: the amount of dye tracer from cellulose patches have quite a few deposits that cannot be detected by a colorimeter.
Table IV. Statistical analysis of the difference among treatments.

| Treatments     | On rice at tillering stage | On rice at booting stage |
|----------------|----------------------------|--------------------------|
|                | MB (farmer) | MK (officer) | MB (officer) | MB (farmer) | MK (officer) | MB (officer) | Boom fan | Boom cone | MB (farmer) | MK (officer) | MB (officer) | Boom fan | Boom cone |
| MK (farmer)    | 0.0146**    | 0.0020**     | 0.0017**     | 0.0032**     | 0.0027**     | 0.0185*      | 0.0018**   | 0.0180**   | 0.0019**    | 0.0019**    | 0.0019**    |
| MB (farmer)    | –           | 0.0632       | 0.0428*      | 0.1820       | 0.1264       | –            | 0.0025**   | 0.0025**   | 0.0035**    | 0.0035**    | 0.0035**    |
| MK (officer)   | –           | –            | 0.2897       | 0.2301       | 0.3040       | –            | –          | 0.9876     | 0.2203      | 0.3731      |
| MB (officer)   | –           | –            | –            | 0.0994       | 0.0927       | –            | –          | –          | 0.2196      | 0.3717      |
| Boom fan       | –           | –            | –            | –            | 0.7165       | –            | –          | –          | –           | 0.6107      |

Notes: Values in the same row followed no symbol are not significantly different at the 0.05 level, according to Student’s t-test. *p < 0.05; **p < 0.01
farmers’ techniques were 2.48–2.71 times higher than those from the rice tillering stage. The increase in height and density at this stage made it rather difficult to maintain a consistent spray in paddy fields at the rice booting stage. From this hindrance, the operation time and spray volume were increased. These impacts were mainly the reason leading to the increase of contamination at the booting stage. The results comply with Thongsakul et al.[8], who measured contamination by this factor of methyl parathion on the body parts of operators varying from 1.2 to 1.5 times with different rice growth stages. On the other hand, this negative impact was not found with the officers’ techniques. This is because the spray direction and increase in height and density made the droplets more settled on the canopy; hence, the droplets produced by the sprayer were blocked from the operator[8, 10].

Extrapolation of the residues on the surface of each body part according to OECD guidelines (OECD 1997) (Figures 1 and 2) revealed that the distribution pattern was relative due to the rice growth stage and the spray application technique. On rice at the tillering stage, all spray application techniques contributed the highest contamination on lower body parts (lower leg and thigh) followed by upper body parts (chest, forearm upper arm and back) and on the hand with the lowest contamination on the head. This result is because lower body parts come easily into contact with the falling droplets on sprayed crops where the height of rice equates to the positions mentioned above.

Extrapolation of the residues on the surface of each body part on rice at the booting stage, the highest deposition of officers’ techniques was found on the upper body parts followed by the lower body parts and on the hand and lowest on the head. In this way, the operator sprayed into the rice rows when the rice was 0.7 m in height, and the result from increasing the height of the rice at this stage forced the operator to carry the spray lance, air tube and boom sprayer equal to those positions mentioned above. The particle sizes of droplets (Table I) remain suspended in the air, are therefore prone to drift and are transported over greater distance by air currents. Therefore, contamination on the upper body parts was more than in other positions. Nevertheless, this effect contrasts with MK (farmer) producing the largest droplets that fell into the bottom of the rice canopy and was the possible reason for the highest deposition found on the lower body.

With respect to the deposition between the left and the right of the body, because of the farmer’s technique of spraying by directly walking into treated crops, the consequent
deposition of dye tracer was found to be non-uniform between the left and the right of the body. While in the officer’s technique, all operators sprayed on the right side of the rice canopy that was relative due to their skills. Thus, the deposition was usually found on the right side of the body.

The data indicate that correct spray application has considerable potential for reducing the contamination experienced by spray operators by 56.96–95.81 percent on rice at the tillering stage and by 89.91–98.23 percent on rice at the booting stage. However, some positions using officers’ techniques cannot reduce the contamination and must be improved because of two reasons. First, the timing of application has an influence in contamination because in Thailand it is not only the wind speed – usually strong after 9.30 a.m. – but also the problem of wind turbulence in this period[18]. In the case of our experiments, we choose that time to conduct our research as we wanted to gain an insight into the contamination at the time that farmers usually work in the fields. Second, the handles of boom sprayers were shorter than the swath width of the spray pattern. In this experiment, the boom sprayers were designed with the handles on each side at 0.5 m. They were not wide enough for swath width, which, on the fan type nozzle, covers 0.9–1 m, and 0.7–0.8 m for hollow cone type nozzles, respectively. The data showed that spraying employing the officer’s technique has an enormous impact on reducing the contamination experienced by spray operators but their percentage was not from all sources. Therefore, the entire body needs to be protected.

Conclusions
It is recommended that each technique must be evaluated again based on field trials to estimate the efficacy for controlling rice insect pests and promoting safe and effective methods to farmers.

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