



## Research Article

# Survey of Pesticide Use between Mango Farmers Practicing Area-Wide Integrated Pest Management and Conventional Farming in West Java, Indonesia

Riya Fatma Sari<sup>1)</sup>, Subejo<sup>2)</sup>, Suputa<sup>1)</sup>, Shanmugam Vijaysegaran<sup>3)</sup>, Stefano De Faveri<sup>4)</sup>, & Y. Andi Trisyono<sup>1)</sup>\*

<sup>1)</sup>Department of Plant Protection, Faculty of Agriculture, Universitas Gadjah Mada  
Jln. Flora No. 1, Bulaksumur, Sleman, Yogyakarta 55281 Indonesia

<sup>2)</sup>Department of Agricultural Socio-Economics, Faculty of Agriculture, Universitas Gadjah Mada  
Jln. Flora No. 1, Bulaksumur, Sleman, Yogyakarta 55281 Indonesia

<sup>3)</sup>Consultant Entomologist  
25 Mabb Street, 4069, Brisbane, Australia

<sup>4)</sup>Queensland Department of Agriculture and Fisheries  
28 Peters St, 4880, Mareeba, Australia

\*Corresponding author. E-mail: [anditrisyono@ugm.ac.id](mailto:anditrisyono@ugm.ac.id)

Received July 10, 2023; revised August 7, 2023; accepted January 11, 2024

## ABSTRACT

Mango farmers in Indonesia rely heavily on pesticides to control a variety of pests and diseases, with tephritid fruit flies being a major pest of the crop. To reduce pesticide use, Area-Wide Integrated Pest Management (AW-IPM) to control fruit flies was tested and introduced in 2015 and has now been successfully implemented in several districts in West Java, Indonesia. This study surveyed pesticide uses in mango farms adopting AW-IPM and those practicing conventional pest control methods. Purposive and Snowball sampling methods were used to select and interview 83 mango farmers to assess farmers' knowledge and practices of pesticide use between the two groups. The farmers surveyed consisted of those that have adopted AW-IPM of fruit flies and those that did not adopt AW-IPM. The results of the survey revealed that compared to conventional farmers, the AW-IPM farmers had a high level of knowledge of pesticides and most of them were aware of pesticide-related environmental risks and adopted better and safer practices. Overall, storage of pesticides within living areas was reported by 10% of respondents, and most respondents (75%) adopted unsafe practices when disposing of used pesticide containers, such as selling them to plastic waste collectors. Half of all the respondents reported and experienced at least one symptom of pesticide-related health problems. This study contributes to a better understanding of potential pesticide exposure and risks to mango farmers in Indonesia. A pesticide management training program for the mango farming community is badly needed.

Keywords: area-wide integrated pest management; exposure; hazards; pesticide use; smallholder mango farmers

## INTRODUCTION

Pesticides are widely used by mango farmers in Indonesia to manage pests and diseases because they are readily available, easy to apply and provide a rapid impact (Rasmikayati *et al.*, 2018). The use of pesticides in mango fields in West Java, which is one of the major areas for mango production in Indonesia, has increased yearly from 2002 to 2009 (Wandschneider *et al.*, 2013). The use of insecticides

to control insect pests, including fruit flies, poses many environmental and human health risks. Thus, it is important to reduce the risks associated with the use of insecticides in mango production in Indonesia. Area-Wide Integrated Pest Management (AW-IPM) is a valuable tool to help reduce the use of pesticides in mango farms. The concept of AW-IPM was developed in the 1800s (Faust, 2008) and it has become the basis for the development of

area-wide management of fruit flies. AW-IPM for fruit flies in Indonesia employs a combination of male annihilation using male lures, low-volume protein bait sprays, sanitation, and population monitoring (Jessup *et al.*, 2007; Vargas *et al.*, 2008). AW-IPM was first tested in mango orchards in the district of Indramayu in 2012 (De Faveri *et al.*, 2014) and has been continuously implemented here and it has now been expanded to the districts of Cirebon (Affandi *et al.*, 2023) and Majalengka as well.

Mango farmers rely heavily on high volume cover sprays of pesticides to protect their mango from a variety of pests and diseases that afflict mangoes. In Indonesia, mango production in 2021 amounted to 2.8 million tons (Statistics Indonesia [SI], 2021). The Province of West Java was the third largest producer of mangoes with the Districts of Cirebon producing 49,426.2 tons; Indramayu 93,397.9 tons; and Majalengka 65,288.9 tons (West Java Open Data [WJOD], 2022). In 2021, the value of fresh Indonesian mangoes exported to Asia reached \$4.56 million USD (Baihaqi, 2014; SI, 2021). Pests and diseases, however, have been the major threats to mango production (Maulida & Andriani, 2022). Labor and pesticides make up most of the production costs (ranging from \$4.3 to \$9 hundred USD/ha/year) (Kusmaryatun *et al.*, 2020).

Many unregistered pesticides are used in mango orchards (Ministry of Agriculture Republic Indonesia [MARI], 2020). Insecticides, fungicides, and herbicides are pesticides frequently used by mango farmers. Carbaryl, carbofuran, and alpha-cypermethrin were the most commonly used insecticides (Supriatna & Sudana, 2008). The fungicides most commonly used are difenoconazole, propiconazole, prochloraz, mancozeb, and propineb, and the herbicides commonly used are paraquat and glyphosate (pers. comm., C. Kurnia & R. Kadarachman, 2022). Over the last 46 years (since 1976), the pattern of pesticide use has varied greatly and has been dependent on the availability of distribution licenses, recognition of health risks and build up of resistance to pesticides (Gaston, 1994), and in 2021, more than a thousand pesticides brands have been registered in Indonesia (Andika & Martono, 2022). To promote the safe use of pesticides and reduce the health impacts of pesticides, Indonesia has enacted

laws and regulations. For example, Regulation of MARI No. 53/PERMENTAN/KR.040/12/2018, concerns the requirements for the quality and safety of fresh agricultural products. Moreover, the intensive application and use of broad spectrum pesticides is causing numerous problems such as pesticide resistance and safety to the operator, consumer, and the environment.

Pesticides pose negative impacts to both the environment and human health when they are extensively and indiscriminately used over time (Shah, 2021). Generally, chemical compounds enter the body through inhalation, ingestion, and dermal absorption. Health issues related to pesticide use include abnormal blood pressure (Prihartono *et al.*, 2022; Rafi'ah *et al.*, 2022), respiratory problems (Mahawati, 2022; Saftarina *et al.*, 2022), and other illnesses. Additional risks from using pesticides include effects on non-target organisms (Zaller & Brühl, 2019), beneficial insects (Murthy *et al.*, 2019; Seide *et al.*, 2018), and polluting the environment (Cassou, 2018).

However, pesticides continue to be a major option for farmers to manage pests, diseases, and weeds despite concerns about their hazards. Education programs to raise pesticide management, community awareness on the storage, handling, and disposal of pesticides, and pesticides used documentation by mango farmers and their impacts are required in Indonesia. This study was conducted to assess pesticide use among mango farmers in West Java with the aim to determine the similarities and differences between AW-IPM and conventional farmers in the knowledge and practices of using pesticides. This study results can be utilized to improve the safety, use, and handling of pesticides in Indonesia.

## MATERIALS AND METHODS

### Study Design

The research was carried out in three districts (Cirebon, Indramayu, and Majalengka) in the Province of West Java (Figure 1). Three farmer groups representing each district, namely Sami Mulya (Cirebon), Angling Darma (Indramayu), and Asosiasi Petani Mangga Kertamulya [APMK] (Majalengka), were selected for the AW-IPM farmer respondents because they have been adopting fruit fly AW-IPM.

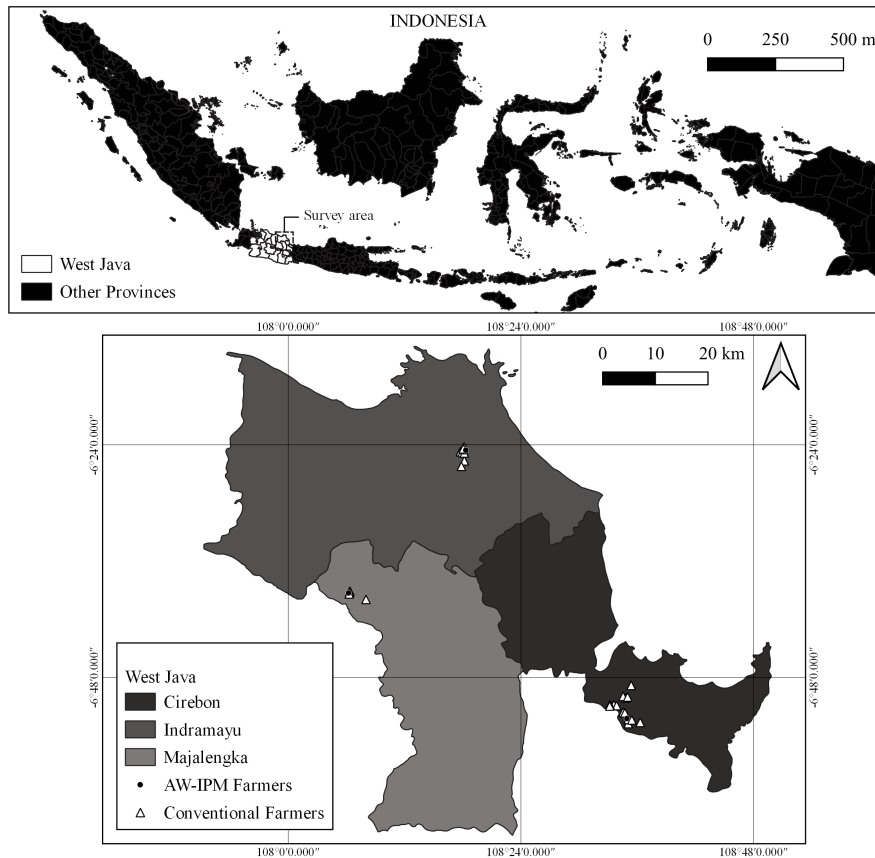


Figure 1. Study area in West Java, Indonesia; AW-IPM (Area-Wide Integrated Pest Management)

Respondents representing conventional farmers were selected from the same districts as the AW-IPM farmers. A total of 83 respondents consisting of 34 AW-IPM farmers and 49 conventional farmers were interviewed individually from October to December 2022. AW-IPM farmers were chosen using the purposive sampling method (Dasgupta, 2003; Eisenhardt & Graebner, 2007; Morse *et al.*, 2002), whereas snowball sampling was used to choose conventional farmers through information provided by pest and disease observers, the agricultural extension officers, and leaders of farmer groups (Noy, 2008).

A personal one-on-one interview was conducted for each respondent. Three major aspects of pesticide use were collected from the interview, including their understanding, handling, and pesticides use correctness. Additional information (age, education, experience, and activities of farmer groups) was gathered to provide the respondent's background. To assist farmers who could not speak or understand Bahasa Indonesia (Indonesia's national language),

interviews were conducted using local language (Sunda) with assistances of an interpreter. All respondents were guaranteed the confidentiality of their answers and the anonymity of their participation. A comprehensive explanation of this study was provided before asking questions and a written informed consent was also collected. The participants were informed that the collected data would be used for academic purposes only. Research approval was granted by The Research Ethics Committee of Universitas Gadjah Mada (KE/UGM/050/EC/2022).

#### Inclusion and Exclusion Criteria

The AW-IPM group surveyed were mango farmers and contractors who practiced AW-IPM, that involved a combination of male annihilation using male lures, low-volume protein bait spot sprays, and sanitation to control fruit flies, as opposed to conventional farmers who did not practice any of these aspects of AW-IPM. Contractors rented mango trees under a contract for one or multi seasons.

All farmers who had used pesticides, and even at least one pesticide, were enlisted for this study. Farmers that did not grow mangoes or had conditions that prohibited them from participating were excluded as respondents.

### Questionnaire

Based on the findings from Dasgupta (2003); Schreinemachers *et al.* (2017); and Utami *et al.* (2020), a questionnaire with structured and semi-structured questions was constructed. We determined and used Cronbach's alpha coefficient value to verify the validity and reliability of the study instrument using a pretested questionnaire on mango farmers in the research area ( $n = 20$ ). Alpha score was 0.86 and implied that the survey revealed had high internal consistency (Effendi, 2012). There were two parts to the questionnaire: the respondents' demographics and farming practices were surveyed in the first section. Demographic factors included location of the farm, age, and educational level of the respondent (Table 1). Meanwhile farming factors included farm ownership, farm size, whether the respondents were member of the farmer group, and how long (year) farmers have been using pesticides (Table 2). The second part consisted of 18 questions. Seven questions measured farmer understanding regarding pesticides use, and this was measured using a three-point scale with responses of have not understood (1), moderately understood (2), and understood (3). Four questions measured pesticides handling and 7 questions measured pesticides use correctness, were measured using a three-point scale with responses of never (1), sometimes (2), and always (3). In addition, respondents were asked about pesticide placement, storage, and disposal. Moreover, we collected information on symptoms and effects of pesticide exposure. Respondents were asked if they had at least one negative health consequence within a year of using or handling pesticides. If the response was positive, respondents were asked to list the symptoms they had experienced. The questionnaires were written in Bahasa Indonesia and translated into English.

### Analysis

Data frequency and percentages were summarized and analyzed on both quantitative and qualitative data. Data from the questionnaire were

transcribed, entered in Microsoft Excel (2019) spread sheet, and checked for any data inconsistencies prior to analysis. We calculated the percentage score by dividing each of the understanding, pesticide handling, and pesticide use correctness scores by their greatest potential score and multiplying them by 100. The interval score was determined by dividing the difference between minimum and maximum scores for each of the understanding, pesticide handling, and pesticide use by their maximum scale. To conduct a descriptive analysis to address the study's objectives, the data were coded, entered into a Microsoft Excel spreadsheet, and checked for errors. This process was repeated for each data set using IBM SPSS Statistics version 29.0.0.0.

Comparisons of characteristics, understanding, handling, and pesticides correctness between the AW-IPM and conventional farmer groups were performed using the Chi-square ( $\chi^2$ ) test. The correlation between understanding, handling, and pesticide use correctness scores were tested by Pearson  $\chi^2$ . Significant predictors of understanding were tested using a multiple logistic regression. Variables included in the regression were selected characteristics with significant p-values  $< 0.05$  in the univariate analysis. As a standard for statistical significance, we chose the value of 0.05, with a null hypothesis that AW-IPM and conventional farmers would respond similarly.

## RESULTS AND DISCUSSION

### Characteristics of Respondents

Many AW-IPM farmers were from Indramayu (47.1%), and Majalengka (47.1%), whereas most conventional farmers were from Cirebon (42.9%). The mean age of AW-IPM farmers and conventional farmers ranged between 36–45 years (41.2%, and 49%; respectively), with an average age of 43 years. Most respondents 41.2% (AW IPM farmers) and 44.9% (conventional farmers) had attended at least elementary school (Table 1). Most of the land cultivated by the respondent was owned or rented from their family or local farmers with 1- to 3-year contracts (52.9% AW-IPM farmers, and 44.9% conventional farmers) (Table 2). The respondents interviewed were typically smallholder farmers with

Table 1. Demographic characteristics of mango farmers in West Java, Indonesia

Description	AW-IPM Farmer <sup>a</sup> (%)	Conventional Farmer <sup>b</sup> (%)	p-value <sup>c</sup>
Age in years	26–35	14.7	14.3
	36–45	41.2	49.0
	46–55	14.7	16.3
	56–65	17.6	12.2
	>65	11.8	8.2
Education level	Did not go to school	5.9	0
	Elementary school	41.2	44.9
	Junior high school	14.7	20.4
	Senior high school	35.3	28.6
	Diploma	0	4.1
	Bachelor	2.9	2.0
Location of farms	Cirebon	5.9	42.9
	Indramayu	47.1	28.6
	Majalengka	47.1	28.6

Notes: <sup>a</sup>Practicing AW-IPM by employing male annihilation and protein bait to control fruit flies, n: 34.

<sup>b</sup>Not practicing AW-IPM, n: 49.

<sup>c</sup>Chi square test ( $\chi^2$ ); \*Significant at 0.05 level of probability.

Table 2. Characteristics of mango farmers in West Java, Indonesia

Description	AW-IPM Farmer <sup>a</sup> (%)	Conventional Farmer <sup>b</sup> (%)	p-value <sup>c</sup>
Farm ownership	Own	17.6	28.6
	Rent	29.4	26.5
	Both	52.9	44.9
Farm size in hectares	≤1	44.1	51.0
	1.1–4	50.0	26.5
	4.1–6	2.9	2.0
	6.1–10	2.9	12.2
	>10	0	8.2
Farmer's group	Non-member	0	49.0
	Member	47.1	22.4
	Managerial farmers	52.9	28.6
Pesticide use experience in years	<6	44.1	46.9
	6–10	20.6	22.4
	11–20	29.4	20.4
	>20	5.9	10.2

Notes: <sup>a</sup>Practicing AW-IPM by employing male annihilation and protein bait to control fruit flies, n: 34.

<sup>b</sup>Not practicing AW-IPM, n: 49.

<sup>c</sup>Chi square test ( $\chi^2$ ); \*Significant at 0.05 level of probability.

farm sizes averaging 0.7 ha, with the majority (44.1% AW-IPM farmers, and 51% conventional farmers) of the respondents having land holdings up to 1.0 ha, and others having land holdings more than 1.0 ha. A small portion of the conventional farmers had mango farms of more than 10 ha (4.82%). All respondents in the AW-IPM group were farmers who had joined the farmer group, compared with conventional farmers, of whom 45% of respondents did not join or belong to a farmer group. Most AW-IPM respondents were part of the farmer group management, who were directly involved as leaders, administrators, and taking roles in the organiza-

tional structure of farmer group. Most respondents had been using pesticides for up to 6 years when they started mango cultivation (44.1% AW-IPM farmers, and 46.9% conventional farmers), meaning most of the respondents in the study area started cultivating and using pesticides around 2018 (Table 2). However, pesticides have been used by previous farmers before the respondents surveyed took over mango cultivation.

The ages (Table 1), farm ownership, and pesticide use experience (Table 2) between AW-IPM and conventional farmers are equal with no significant difference between the two groups. In contrast, edu-

cation levels, the location of farms (Table 1), farm size, and farmer's group (Table 2) between AW-IPM and conventional farmers are not equal, and the *p*-value is less than 0.05, showing a significant difference between AW-IPM and conventional farmers. Extension or training provided by the government, or the local Agriculture Service had been conducted for selected farmer groups (Rasmikayati *et al.*, 2018), and our study that showed some farmers had received AW-IPM extension/training in Cirebon compared to the other locations. The AW-IPM farmers in Cirebon faced problems with the lack of farmers' activity and weak leadership in groups. Interaction among farmers in the farmer groups is a useful way to share their experiences, to find solutions when facing problems and to deliver information to each other (Esperanza *et al.*, 2018).

### Respondent's Understanding of Pesticides

With regard to types of pesticides, residues and pesticides labels, there was a significant difference in understanding between AW-IPM farmers and conventional farmers ( $\chi^2$  15.749, *p* < 0.05). AW-IPM farmers and conventional farmers understood active ingredients (score of 86.3, and 76.2, respectively Table 3). The respondents considered pesticides harmful to their health with a score of 100 for AW-IPM farmers and 92.5 for conventional farmers. Pesticides pose some risk to the environment, according to the response of AW-IPM farmers that had average scores of 75.5 implying they understood, and conventional farmers had a moderate understanding of this issue. All the respondents reported that they would like to have a better understanding of pesticide risk. They all understood that pesticides

were crucial for maintaining crop productivity. Overall, the AW-IPM farmers who were surveyed demonstrated more solid knowledge of pesticide use than conventional farmers. However, this does not necessarily mean that the AW-IPM farmers are always better in adopting good practices for pesticide use. There are several factors contributing to change in practice, and these include behavior, self-confidence, coordination, the concept of justice, economic incentives to prioritize pursuit, and the ability to make changes (Cassou, 2018; Hamilton *et al.*, 2022). One of the factors is that farmers who are part of farmer group management have a higher propensity to understand pesticides. This is inherent to coordination because farmer groups that can access to extension services and the government are more likely to change their pesticide practices.

### Respondent's Practices on Handling of Pesticides

The AW-IPM and conventional farmers always stored the pesticides according to instructions on the label (Table 4), such as in a warehouse. They always locked the places of storage to keep pesticides out of the reach of children and pets. After a round of spraying, they only rinse the sprayer occasionally (Table 4), and when they did, they disposed the pesticide rinse in the field (38.2% and 32.7%, respectively, Table 5). In addition, respondents reported to using the same pesticide spraying equipment for both insecticide and fungicide, while different ones were used for herbicide application. They used sprayers with an automatic control system and were able to spray pesticide solutions with accuracy (Table 5). When asked if they reuse pesticide packages for other purposes, most AW-IPM farmers responded

Table 3. Criteria used to assess farmer understanding of pesticides

Understanding	AW-IPM Farmer <sup>ac</sup>	Conventional Farmer <sup>bc</sup>
Active ingredients	86.3	76.2
Differences between insecticides, fungicides, and herbicides	95.1	85.7
Pesticide residue on mango fruit	43.1	46.9
Reading compliance with the pesticide labels	65.7	50.3
Effects of pesticides on health	100	92.5
Effects of pesticides on the environment	75.5	60.5
Importance of pesticides for protecting crop yield	85.3	95.2

Notes: <sup>a</sup>Practicing AW-IPM by employing male annihilation and protein bait to control fruit flies, n: 34.

<sup>b</sup>Not practicing AW-IPM, n: 49.

<sup>c</sup>Scores understanding pesticides have a possible range of 0–33.3 (have not understood), 33.4–66.7 (moderately understood), and 66.8–100 (understood).

Table 4. Attitudes on pesticide handling

Handling practices	AW-IPM Farmer <sup>a</sup>	Conventional Farmer <sup>b</sup>
Store pesticides prescribed on the label	99	89.1
Store pesticides away from children and pets	99	93.2
Triple-rinse the sprayer (hose and nozzle)	56.9	57.1
Reuse empty pesticide packages for other purposes	56.9	97.3

Notes: <sup>a</sup>Practicing AW-IPM by employing male annihilation and protein bait to control fruit flies, n: 34.

<sup>b</sup>Not practicing AW-IPM, n: 49.

<sup>c</sup>Scores pesticide handling have a possible range of 0–33.3 (never), 33.4–66.7 (sometimes), and 66.8–100 (always).

Table 5. Practices adopted by mango farmers in handling, storage and disposal of pesticides

Practices	AW-IPM Farmer <sup>a</sup> (%)	Conventional Farmer <sup>b</sup> (%)
Type of pesticide applicators <sup>c</sup>		
Automated Backpack Sprayer	85.3	51.0
Static Power Sprayer	44.1	59.2
Pesticides storage		
Locked chemical store	8.8	4.1
Living area	5.9	10.2
In a special location (in the house)	52.9	36.7
Warehouse (agricultural tools and equipment)	32.4	49.0
Dispose of rinsed pesticide <sup>d</sup>		
In the field	38.2	32.7
In sewer	0	8.2
Dispose of empty pesticide containers <sup>c</sup>		
Dispose to a container collection site	0	2.0
Sell to plastic waste collectors	67.6	69.4
Discard on-farm	8.8	6.1
Buried/burned	26.5	22.4
Stored in a special place	14.7	6.1

Notes: <sup>a</sup>Practicing AW-IPM by employing male annihilation and protein bait to control fruit flies, n: 34.

<sup>b</sup>Not practicing AW-IPM, n: 49.

<sup>c</sup>Multiple responses allowed.

<sup>d</sup>Respondents were asked if they rinse the sprayer.

neutral (score of 56.9) while conventional farmers always did (score of 97.3) (Table 4). They reported reusing empty pesticide containers for farm purposes. Disposal of empty pesticide containers is often done by burying/burning them (24%), storing them in special places (9%), disposing them in the field (7%), or returning pesticides to retailers (collection site) (1%) (Table 5). A worrying 68% of the respondents reported selling pesticide packages to plastic waste collectors. However, before doing so, they scratched out all identifying information on the pesticide label and crushed the containers to prevent pesticide counterfeiting. AW-IPM farmers preferred to store used pesticide containers in a special place compared to conventional farmers. An insignificant association ( $\chi^2$  3.47,  $p > 0.05$ ) was observed between respondent groups and pesticide storage, rinse, and disposal.

In both AW-IPM and conventional farmer groups, some farmers practiced incorrect use, storage, and disposal of pesticides. They understood the importance of wearing protective gear (e.g., goggles and a mask) when spraying pesticides on their farm, but in practice some did not do so. The complexity of using the proper protective equipment was the reason they gave during an interview in the survey. Instead, they preferred to just use a hat with built-in face masks used for fishing purchased in local markets, or they wrapped a scarf or a t-shirt over their face when spraying pesticides. Another undesirable practice involved the storage of pesticides in living areas or in the house. Many farmers understood that pesticides are highly toxic and should never be in direct contact with humans and they also pose risks to animals. The final issue involved

the disposal of used pesticide containers and packaging. Respondents mentioned that they do not read the instructions on how to rinse off pesticides and dispose of the containers. They used improper disposal methods, such as rinsing the pesticide containers in the field, pouring the rinse down the sewer, discarding empty pesticide containers in the field, burying/burning containers on the farm, or selling them to plastic waste collectors. They believed that pesticide container disposal practices were safe as long as they kept the empty pesticide containers away from other family members and animals. Incorrect use, storage, and disposal of pesticides were also previously reported by Matthews (2008), showing that smallholder farmers in 26 countries, including Indonesia, stored pesticides in their houses or on outdoor land and rarely or never locked them in storage. In addition, the smallholder farmers disposed empty pesticide packages at the collection sites (Istriningsih *et al.*, 2022; Pasiani *et al.*, 2012). These practices suggest that farmers' behaviors might be related to their lack of technical expertise and training in the correct use of pesticides.

### Respondent's Correct Use of Practices

The category of farmers was not significantly associated with correct pesticides use practices ( $\chi^2$  0.54,  $p > 0.05$ ). There was no significant difference between AW-IPM and conventional farmers regarding following label instructions, dosage measurement, spraying time, targeting pests, applying proper cocktails, and wearing protective equipment. For example, in both groups, farmers sometimes followed prescribed instructions on the label, such as measuring dosage and wearing protective equipment. Most participants appeared to take few pre-

cautionary measures when using pesticides. For responses regarding the use of protective equipment, the overwhelming majority reported wearing masks while applying pesticides. For instance, both AW-IPM and conventional farmers reported that they wore hats with built-in face masks (Table 6). Meaning that they were not wearing the correct masks. With an approximate score of 90, they could identify pesticide's target, especially insect pests. Thus, AW-IPM farmers used specific pesticides to control different targets such as insects, and diseases. In contrast, conventional farmers used several different pesticides to control the same pest or disease.

The understanding level of pesticides was the main distinction between AW-IPM and conventional farmers (Table 3). Farm size and membership in a farmer group showed a significant correlation in the association analysis (Table 7). In contrast, factors such as the education level, and farm location had no correlation with farmers' knowledge, pesticide handling, and correct pesticides use (Table 7). The findings also showed that there was no association between membership in farmer groups and practices related to handling and correct use of pesticides, nor was there any association between farm size and farmers' knowledge and practices related to pesticide handling. This means that knowledge of pesticides did not seem to encourage farmers' practices over the handling and correct use of pesticides.

When questioned over their understanding of pesticide use and awareness AW-IPM farmers showed that they were aware of its impact on health and the environment. In other studies, the understanding of pesticide use was also influenced by farmer safety behavior and an understanding of the health

Table 6. Compliance with the correct use of pesticides

Correct Use of Pesticides	AW-IPM Farmer <sup>a</sup>	Conventional Farmer <sup>b</sup>
Follow pesticide use directions	53.9	53.7
Measure the pesticide dosage prescribed on the label	52.0	51.7
Apply pesticides at the right time	98.0	93.2
Determine the target pest for the proper pesticide	94.1	97.3
Applying proper pesticides cocktail	42.2	92
Wearing mask	69.6	70.7
Wearing goggles	41.2	38.8

Notes: <sup>a</sup>Practicing AW-IPM by employing male annihilation and protein bait to control fruit flies, n: 34.

<sup>b</sup>Not practicing AW-IPM, n: 49.

<sup>c</sup>Scores for pesticide correctness have a possible range of 0–33.3 (never), 33.4–66.7 (sometimes), and 66.8–100 (always).



Table 7. Comparison between respondents of the level of pesticide understanding, handling, and correct use

Variable (n: 83)	$\chi^2$			
	EL <sup>a</sup>	LF <sup>b</sup>	FS <sup>c</sup>	FG <sup>b</sup>
Understanding	15.52	1.37	13.44	11.65*
Handling	6.16	6.06	7.45	2.29
Correct use	8.05	6.55	17.47*	8.92

Notes: Selected characteristics: EL (education level), LF (location of farms), FS (farm size), and FG (farmer's group).

The Chi-square test ( $\chi^2$ ) was used to determine the value of comparison statistic.

Values ( $\chi^2$ ) followed by an asterisk (\*) for each row were significantly at 0.05 level of probability; adf: 10; bdf: 4; cdf: 8.

risks (Damalas & Koutroubas, 2014). Most AW-IPM farmers mentioned that the application of pesticides was necessary to prevent the occurrence of pest and disease attacks. This revealed that they were aware of the risks of doing nothing to prevent pest and disease attacks. However, AW-IPM farmers also implemented other methods for controlling fruit fly pests in mango such as male annihilation, protein baiting, and sanitation, hence pesticides were not the only way farmers adopted to protect mango. Mwungu *et al.* (2020) and Rahman *et al.* (2021) reported that AW-IPM program impacted farmers' knowledge and decreased pesticide use. As these farmers have practiced farming their whole lives, their knowledge and practices were greatly influenced by their fellow farmers. The main trusted sources of information were fellow farmers and agriculture officers. However, this factor alone was not sufficient to motivate farmers to change their behavior to use pesticides correctly. This could provide an opportunity to assign fellow farmers to per-

suaude and encourage others to apply pesticides correctly.

Based on multivariable regression (Table 8), only one factor significantly and positively contributed to the variance in the correct use of pesticides. The survey also showed that farmers with a farm size less than 1 ha were 0.62 times more likely to use pesticides correctly, and that large farms were less likely to use pesticides correctly. Farmers' education levels, farm locations, and membership in the farmer's group, on the other hand, were not significantly correlated with the correct use of pesticides. The findings also showed that there was no significant correlation between farmers' understanding, farmers' education levels, farm locations, farm size, and membership in farmer groups.

In practice, the farmer's experience in cultivating other agricultural products might also contribute to their pesticide use patterns. In addition, they believed that applying pesticides on mango fields was safer compared to application to rice on paddy fields. This finding is consistent with previous studies in Indonesia (Istriningsih *et al.*, 2022; Mahyuni *et al.*, 2020), Southern India (Sai *et al.*, 2019); and Turkey (Öztaş *et al.*, 2018) which reported/found that farmers know and understand the correct way to use pesticides. However, they did not necessarily apply this knowledge in the field.

### Self-Reported Health Effects Related to Pesticides

The majority (>80%) of respondents stated that they had experienced negative health effects after incorrect use or handling of pesticides whereas 10% of conventional farmers reported that they did not experience any health issues upon exposure to pes-

Table 8. Logistic regression between respondents regarding the level of pesticide understanding, and correct use

Independent variable <sup>b</sup>	Understanding <sup>a</sup>			Correct Use <sup>a</sup>		
	$\beta$	S.E.	p-value	$\beta$	S.E.	p-value
Education level	0.857	0.529	0.105	0.219	0.341	0.519
Location of farms	0.305	0.705	0.665	-	-	-
Farm size	0.173	0.442	0.695	0.624	0.271	0.021*
Farmer's group	1.674	1.047	0.109	0.422	0.522	0.419
Constant	-8.312	3.360	0.013*	-4.501	1.222	0.000***

Notes: <sup>a</sup>Dependent variables: 1: understood/always, 0: others, see Table 3 and Table 6.

<sup>b</sup>The selected characteristics of farmers.

$\beta$  (coefficient of the predictor variables); S.E. (standard error).

Level of significance: \*\*\* ( $p \leq 0.000$ ); \* ( $p \leq 0.05$ ).

ticides (Figure 2). Dizziness (40%), skin irritation (40%), poor vision (30%), and nausea/vomiting (20%) were the symptoms that were most frequently mentioned by respondents. Other symptoms mentioned by respondents were shortness of breath, loss of appetite, and diarrhea. When asked what they did after a poisoning incident, all the respondents said they did nothing because it was a minor incident that simply required rest. To prevent poisoning, they have eaten before spraying pesticides, but it is unclear whether this would decrease their risk of exposure to pesticides. Respondents who did not experience symptoms of pesticide exposure were excluded from the analysis.

An understanding of the health and environmental impacts of the incorrect use of pesticides by AW-IPM farmers, unfortunately is not followed by their willingness to read and comply with the information provided on the pesticide label. The farmers perceived this as a complicated task and they claimed that they already knew all the information on the label. Information on pesticides has also been communicated to farmers by pesticide salesman and fruit collectors. This practice could put farmers at a higher risk due to potential misinterpretation of the information on safe-handling and use as written on the label. Sabran and Abas

(2021) reported that such behavior correlates with farmers being unaware of the dangers of pesticide residues, which in turn might be influenced by farm size, education level, and farming experience. Farmers awareness on the consequences of improper pesticides use was related to their awareness of health risks due to exposure to pesticides. Health issues through symptoms experienced by farmers were recorded in the interviews. The lack of knowledge related to the impact of pesticides on health increased the risk of farmers using pesticides incorrectly.

The correct use of pesticides will minimize undesirable effects of pesticides and their impacts on human health. From the results of this study, we can conclude that a high level of understanding on pesticides did not correspond with correct pesticide use. Examples of pesticide misuse found in this study include poor compliance with reading pesticide labels before use, triple-rinsing the sprayer, reusing empty pesticide containers for other purposes, incorrectly measuring the pesticide dosage as prescribed on the label, applying proper pesticides as a cocktail, and not wearing gloves and proper masks during application. Such behavior requires further intervention and farmer group should be the main targets due to their high level of understanding and correct pesticides use combined with their large farm size. In contrast, previous findings of Mwangi *et al.* (2020) demonstrated that farmer groups did have a negative impact on AW-IPM technology adoption, including pesticides usage because of individual limitations on farmer-group dynamics. Our results highlight the farmer group is very important to improving mango farmers' knowledge and understanding because it connects them to lectures, group discussions, farmer field schools, field visits, and other extension techniques with plant pests and disease observers, extension officers, and researchers. This study also found that correct use of pesticides is positively correlated with farm size. The results of the interviews conducted with the farmers showed that most of them have less than 4 ha of mango and most of it is private and rented property. A study by Migheli (2017) found that farmers used pesticides more correctly and safely if they rented the cultivated land (Migheli, 2017). Another study by Sabran and Abas (2021)

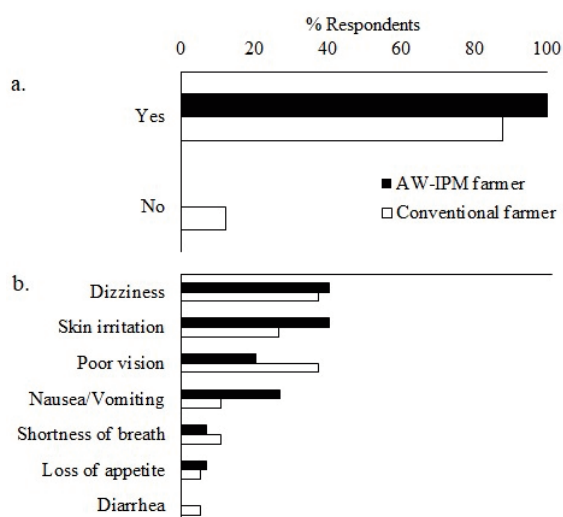


Figure 2. Health effects of pesticide use; (a) perceived pesticides' health effects; and (b) symptoms. The respondents were asked if they experienced at least one symptom immediately after applying or handling pesticides, and multiple responses were allowed.

found that farmers with small farm sizes and owning cultivated land had a higher level of awareness of pesticide use and the associated risks and used pesticides more wisely.

## CONCLUSION

The average level of knowledge of the AW-IPM farmers on the correct use of pesticides was higher than conventional farmers. However, there was no difference in attitude toward pesticide handling and compliance with correct use of pesticides between AW-IPM and conventional farmers. However, the AW-IPM farmers always correctly handled empty pesticide containers, did not reuse containers, and stored pesticides in a safe place. Variations in the dosage of pesticides applied, poor pesticide waste management, and improper personal protective equipment may lead to high exposure and pesticide poisoning, and these issues need to be urgently addressed. Farm size was the only parameter that showed a positive and significant relationship with the farmers' correct use of pesticides. Proper training and implementation of AW-IPM focus on (i) the development of AW-IPM, which will address significant limits in current pesticide management; and (ii) the search for new methods to increase yields while using less pesticide and insulating against pests and diseases is urgently required to improve the complex issue of pesticide management, and which will lead to the safe handling and correct use of application of pesticides in mango farms in Indonesia.

## ACKNOWLEDGEMENTS

We are grateful to the mango farmers and the plant pests and diseases observers (POPT) in the research areas for helping us with data collection. We gratefully acknowledge Siti Fatonah, and Aswindu Mukti Kurnia Wati for their advice on interpreting this manuscript's results. Valentina Erline Febry Aryuwandari for her comments and suggestions on the draft of this manuscript. Carole Wright, the Department of Agriculture and Forestry, Queensland government reviewed the statistical analyses. Funding for this research was provided by the Australian Centre for International Agricultural Research. This article is a part of the first author's Master's thesis.

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