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Role of Farmers' Training on Improving Pesticide Management and Food Safety in Conventional Cabbage and Eggplant Production

John Julius P. Manuben*, Jasper A. Sarmiento, Eric Jhon D. Cruz[a], Allan Adrian B. Galao[a], and Cristina M. Bajet[b]

National Crop Protection Center, College of Agriculture and Food Science,
University of the Philippines Los Baños, College, Laguna 4031 Philippines

Pesticides pose a serious risk to the environment and public health when used in crop production in an unsafe and indiscriminate manner. Moreover, there is a preconceived notion that conventionally grown crops are not as safe as organic crops due to the presence of pesticide residues. To address this, an intervention that focused on farmers' training on proper pesticide management was conducted. Two farmer clusters were organized separately, and pesticide usage and practices were monitored and evaluated. The results of the evaluation indicated a significant decline in the usage of pesticides not registered for cabbage and eggplant production. Residue analysis for major insecticide groups (organochlorines, organophosphates, and pyrethroids) of the harvested crops showed that 100% of the eggplant samples (n = 20) and 80% of the cabbage samples (n = 20) had non-detectable pesticide residues (< 0.01 mg/kg). The cabbage samples with detectable residues are found to be compliant with the currently established CODEX and ASEAN maximum residue limits for the indicated pesticides. Overall, this suggests that training and monitoring activities conducted to strengthen the knowledge and adherence to pesticide safety practices resulted in safe conventional vegetable production. It is recommended that farmers' training and other extension activities be conducted periodically to promote the judicious use of pesticides for food safety.

Keywords: training, pesticide management, pesticide residues, food safety, conventional

INTRODUCTION

In most circumstances, pesticides are unavoidable, particularly in major agricultural regions when pest pressure is high and farmers have no other options for biological, microbiological, or mechanical management. Farmers use pesticides to improve crop quality, yield and allow for more stable income (Cooper and Dobson 2007). Unwanted consequences of pesticides typically result from over-reliance, incorrect usage, and limited access to proper pesticide management training. Moreover, poor handling practices of pesticides may result in the contamination of the environment (Silva *et al.* 2019; Riedo *et al.* 2021; Silva-Madera *et al.* 2021; Bexfield *et al.* 2021) and agricultural commodities (Ma *et al.* 2022; Nguyen Dang Giang *et al.* 2022; Park *et al.* 2022). In the Philippines, some studies reported the presence of pesticide residues on freshly harvested vegetables (Lu 2011; Cubelo and Cubelo 2021) and conventional and organic vegetables sampled from the market (Manuben *et al.* 2022) in which one sample exceeded the European Union (EU) maximum residue limit (MRL) for chlorpyrifos and profenofos residues in *pechay*.

*Corresponding author: jpmanuben@up.edu.ph
[a]Formerly affiliated; [b]Retired

Smallholder conventional vegetable producers may tend to overuse synthetic insecticides to protect their investment from various insect pests and diseases (Praneetvatakul *et al.* 2022). In some cases, the current market price affects the farmers' decision to readily harvest, thereby disregarding the pesticides' pre-harvest interval (PHI) or the period between the last pesticide application and harvest. This, in turn, could result in high pesticide residues in the commodity. However, conventionally grown crops can also be as safe as organic crops and "pesticide-free" grown vegetables provided that proper pesticide management is followed. Pesticide management encompasses pesticide production up to its disposal. This aims to ensure efficacy, and safety, and minimize negative effects on human and animal health and the environment (FAO/WHO 2014). Pesticide residues in the product will have levels lower or equal to its MRLs when good agricultural practice (GAP) is considered in the production (WHO 2022). An MRL is a trading standard and a measure of the highest level of pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly (FAO/WHO n/d). Foods with residue levels within their respective MRLs can be assured of safety since MRLs are always set far below food safety margins and, therefore, are suitable for consumption (Winter and Jara 2015; FAO/WHO n/d; EU 2022). However, it must be noted that the MRLs do not directly reflect the level of pesticide residues safe for human exposure but merely represent the GAP that farmers should follow during production (Halimatunsadiah *et al.* 2016).

Numerous studies have been implemented about the importance of training and education on the improvement and promotion of proper pesticide handling and safe usage. The training was considered a key solution for lowering farmers' pesticide exposure (MacFarlane *et al.* 2008) and improving the farmers' knowledge and attitude toward pest management (Gautam *et al.* 2017). Training and extension workshops were deemed as reliable and affordable extension delivery tools to meet the specific training needs of farmers and encourage proficiency in areas where farmers have rather poor skills (Hashemi *et al.* 2012). Meanwhile, training of smallholder farmers in farmers' field schools in Bolivia showed a sustained improvement in personal protection involving pesticide application, and their knowledge about IPM and other alternative methods in pest control was enhanced (Jors *et al.* 2014). However, farmers' differences in competencies and knowledge uptake should be considered regarding the conduct of these interventions.

This study aims to explore the role of farmers' training and monitoring on farmers' knowledge of pesticide selection and practices that will result in pesticide residues compliant with the MRLs and, therefore, will assure consumers' safety. The study was implemented on the eggplant-producing farmers in Dolores, Quezon, in Region IV-A, and on the cabbage-producing farmers in Buguias, Benguet in the Cordillera Administrative Region (CAR). Region IV-A was the second largest eggplant producer, accounting for 12.9% of the national eggplant production in the fourth quarter of 2022 (PSA 2023). Meanwhile, CAR was the largest cabbage producer in the country, contributing to 80.5% of the national cabbage production in the fourth quarter of 2022 (PSA 2023).

METHODOLOGY

Study Area and Selection of Farmer Cooperators

The study was conducted from January–December 2018 and covered two locations (Figure 1). Eggplant production in Region IV-A was considered the second largest in

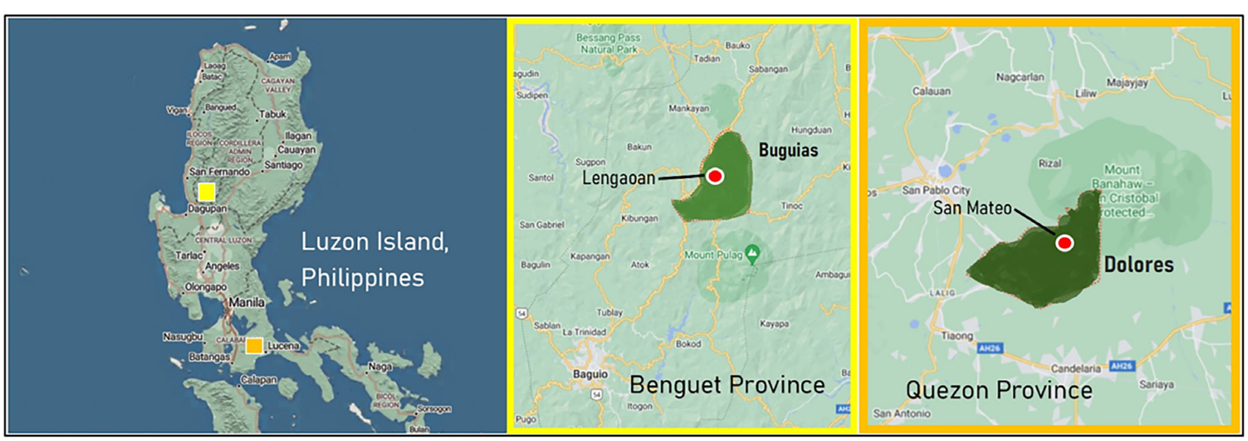

Figure 1. Map (left) showing the sites of the study in the Philippines: Lengaoan, Buguias, Benguet (in yellow) and San Mateo, Dolores, Quezon (in orange). The middle and right images show where Lengaoan and San Mateo are located, respectively. They are marked red, whereas their respective towns are colored green.

terms of volume (PSA 2023). Several eggplant-producing municipalities in the region were shortlisted as study sites, however, San Mateo, Dolores, Quezon was selected due to the presence of an established farmer association with enough eggplant farmer cooperators. Meanwhile, Lengaoan, Buguias, Benguet was chosen as the study site since it is a major cabbage-producing area in CAR.

Purposive sampling, a non-probability sampling method, was used to select prospective participants based on the judgment of the researchers (Baxter and Babbie 2003). In this sampling method, the study sample is specific and not representative of the population; however, the selected participants are considered to provide the information needed in the study. The participants of the study were smallholder farmers engaged in the conventional production of eggplant and cabbage. Mobilization and linkage with farmers and the local government units (LGUs) of San Mateo, Dolores, Quezon, and Lengaoan, Buguias, Benguet were initiated, which resulted in the participation of 37 eggplant farmers and 40 cabbage farmers, respectively. The presence of an existing organization of farmers on the selected sites ensures well-coordinated communication among farmer members and quick dissemination of information. The criteria for the selection of the farmer cooperators include [1] willingness to participate, [2] producer of either eggplant or cabbage, and [3] ability to sustain the operation of the farm.

Data Collection and Capacity Building

The prospective farmer participants were smallholder farmers engaged in conventional eggplant and cabbage production. Structured questionnaires, formal interviews, and field monitoring were used to gather information. The structured questionnaire contained two sections. The first section was intended to gather information on the farmer participant's age, education, planting area, farming experience, and attendance to training. The second section aimed to list all the pesticides used by the participants from the previous planting season. In addition, formal interviews and field monitoring were conducted to determine the pesticide usage of the farmer participants after the intervention. Key information such as the pesticide selection, frequency of application, and PHIs was also recorded to better understand the effect of the intervention provided in their practices and further on food safety.

Training and workshop were provided to the farmer participants to improve their knowledge of proper pesticide management and food safety practices. Various experts from different fields were invited as resource speakers. The pesticides recommended for eggplant and cabbage and food standards from international and national sources were introduced followed by a workshop. The training took place in a convenient location very near the two sites for 3 d. Other topics included in the training were pest management, record keeping, pesticide reduction strategies, and marketing. Information, education, and communication materials were also provided to the farmer participants to be used as guides.

Farm Monitoring and Pesticide Residue Analysis

Farm activities were monitored through farm visits and the use of record notebooks. This activity allows researchers to track progress and schedule the harvest for sample collection. Twenty (20) farmers were randomly selected from each study site, and 1–2 kg of the sample was collected for pesticide residue analysis using gas chromatography–mass spectrometry (GC-MS). Twenty (20) eggplant and cabbage samples were submitted to the National Pesticide Analytical Laboratory of the Bureau of Plant Industry (BPI-NPAL) in Quezon City and the Satellite Pesticide Analytical Laboratory in Baguio City, respectively. A multi-residue method that covers the analysis of 11 organophosphate pesticides (mevinphos, dimethoate, diazinon, isazophos, methyl parathion, fenitrothion, malathion, chlorpyrifos, phenthoate, profenofos, and triazophos), six pyrethroids (lambda-cyhalothrin, permethrin, cyfluthrin, cypermethrin, fenvalerate, and deltamethrin), and eight organochlorines (lindane, aldrin, heptachlor, alpha and beta endosulfan, endosulfan sulfate, heptachlor epoxide, and 4,4-DDE) was used. The results obtained were evaluated against the CODEX MRLs, Association of Southeast Asian Nations (ASEAN) MRLs, and EU MRLs.

Data Analysis

Descriptive statistics (relative frequencies, averages, and percentages) were calculated for most of the variables measured in the study. The use of McNemar's test and the two-tailed binomial test were employed to determine the effect of training on the pesticide usage of cabbage and eggplant farmers, respectively.

RESULTS

Characteristics of the Farmer Participants

The primary characteristics of the farmer participants are presented in Table 1. The average age of the cabbage and eggplant farmers was 49 and 42 yr old, respectively. The average educational attainment of the farmers was at least high school level and with farming experience of more than 20 yr for both groups. The land area dedicated to farming was below 0.50 ha. Moreover, most of the cabbage farmers received previous training related to production and crop protection as compared to eggplant farmers.

Table 1. Basic characteristics of the farmer participants.

Parameters	Cabbage cluster	Eggplant cluster
Age (yr; ave.)	49	42
Education (0–5; levels*)	2.925	2.79
Area planted (ha; ave.)	0.3225	0.4347
Farming experience (yr; ave.)	25	28
Previous training experiences (0–1)	0.95	0.44

*[0] elementary level, [1] elementary graduate, [2] high school level, [3] high school graduate, [4] college level, and [5] college graduate

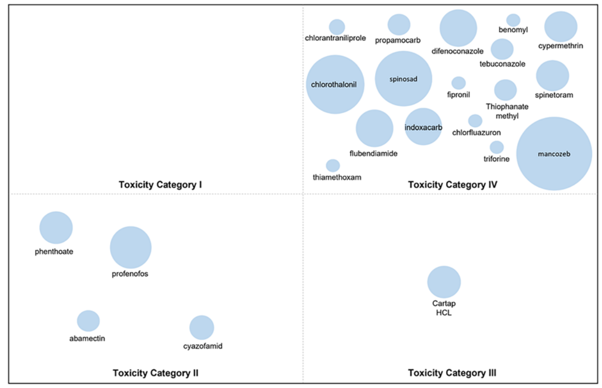

Figure 2. Toxicity category and pesticide use frequency of farmers in Lengaoan, Buguias, Benguet, Philippines for cabbage production (the area of the circle corresponds to the number of farmers who used the pesticide).

Pesticide Usage by Cabbage and Eggplant Farmers

Data about pesticide usage from the previous season for both clusters were also determined. Based on the results, cabbage farmers were using 22 different pesticide active ingredients with each farmer using more than one pesticide to control various pests and diseases (Figure 2). Spinosad (57.5%) was the most widely used insecticide, followed by profenofos (27.5%) and indoxacarb (22.5%), with the remaining 11 active ingredients being used by < 17% of the cabbage farmers (Figure 3). Spinosad and indoxacarb were used for the control of the diamondback moth, a major insect pest in cabbage. Being classified as toxicity Category IV, these insecticides have the lowest toxicity as compared to others such as profenofos, which belong to toxicity Category II. Mancozeb (75%) was the most widely used fungicide, followed by chlorothalonil (37.5%) and difenoconazole (22.5%) (Figure 3). These fungicides are classified as toxicity Category IV and are registered for the control of diseases such as downy mildew and powdery mildew, *Alternaria* leaf spot, and ring spot. Most of the farmers were mixing pesticides to lessen their labor costs and time in the field.

Meanwhile, eggplant farmers were using nine different active ingredients for the control of insect pests and diseases in eggplant. As shown in Figure 4, most of the farmers were using pesticides under toxicity Category IV, and none were using toxicity Category I and III pesticides. Most of the farmers were using thiamethoxam and the fertilizer-containing product with methomyl at 32.5% usage, followed by profenofos at 15% (Figure 5). The

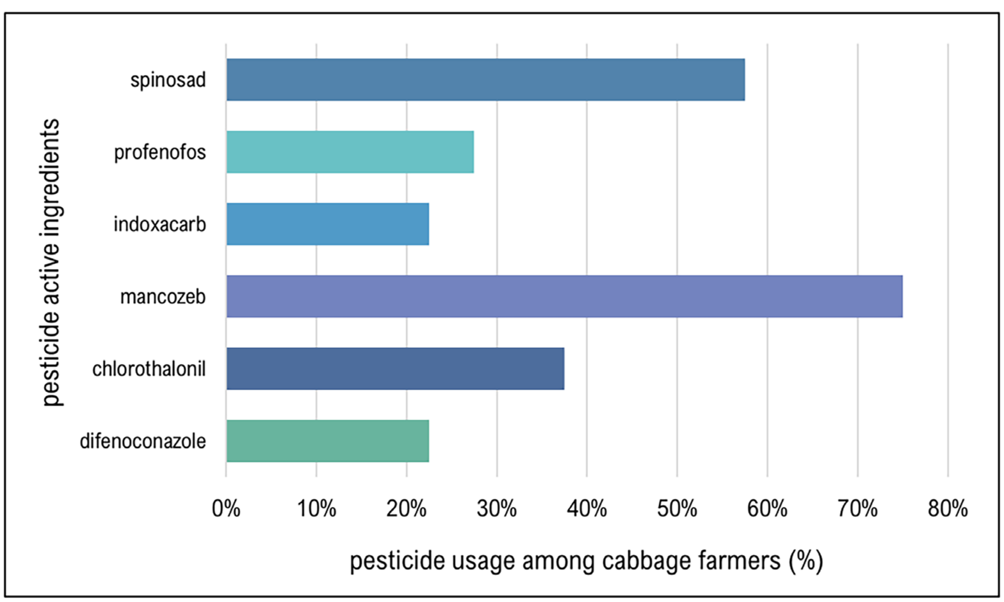

Figure 3. Most used registered insecticides and fungicides by the cabbage farmers in Brgy. Lengaoan, Buguias, Benguet, Philippines.

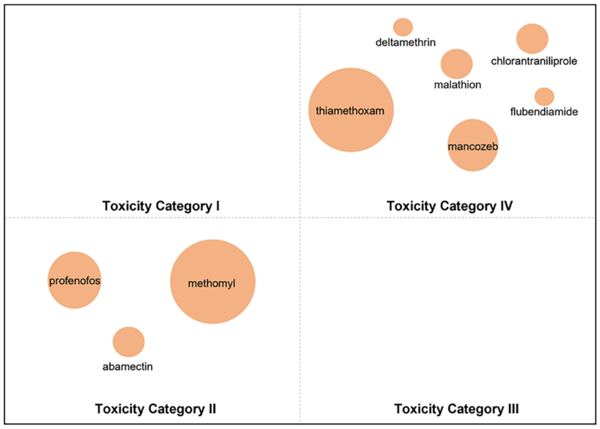

Figure 4. Toxicity category and pesticide use frequency of farmers in San Mateo, Dolores, Quezon, Philippines for eggplant production (the area of the circle corresponds to the number of farmers who used the pesticide).

fungicides mancozeb and chlorothalonil were the only active ingredients being used at 17.5 and 7.5%, respectively.

Moreover, there were nine different active ingredients used by cabbage farmers that were not registered specifically for cabbage based on the list from the Fertilizer and Pesticide Authority (FPA 2023). Around 87% of the cabbage farmers (34 out of 40) were using lambda-cyhalothrin insecticide, and 65% (26 out of 40) were using the fungicide propineb, a fungicide registered for *wombok* or Chinese cabbage (Table 2). Other insecticides being misused were chlorpyrifos and carbofuran at 20 and 12%, respectively. Both active ingredients are under toxicity Category II and possess a long residual half-life. Overall, 29% of the identified active ingredients for both insecticides and fungicides used by the farmers were not registered for cabbage. Most of the pesticides not registered for cabbage used by farmers in Buguias, Benguet were under toxicity Category II.

For eggplant, there were eight different active ingredients used by farmers that were not specifically registered for the crop (FPA 2023). Lambda-cyhalothrin insecticide was used by 29% (11 out of 37) farmer respondents followed by carbaryl, cypermethrin, and chlorpyrifos + BPMC (Table 3). Overall, 47% of the identified active ingredients for both insecticides and fungicides used by the farmers were not registered for eggplant. Most of the pesticides not registered for eggplant used by farmers in Dolores, Quezon were under toxicity Category II.

Relationship between Training and Pesticide Usage and Results of Pesticide Residue Analysis

A comparison of the pesticide usage of both clusters before and after the training was prepared. Results showed that 33 of the 40 cabbage farmer respondents (82.5%) were previously found to be using at least one non-registered pesticide for cabbage (Figure 6). After the interventions provided, the number of farmers using the incorrect pesticide for cabbage decreased to 10 out of 40 farmers (25%). As for the eggplant farmers, the previous data showed that 21 out of 37 farmers (57%) were using at least one non-registered pesticide but after the interventions provided, this decreased to 10 out of 37 farmers (27%) (Figure 6).

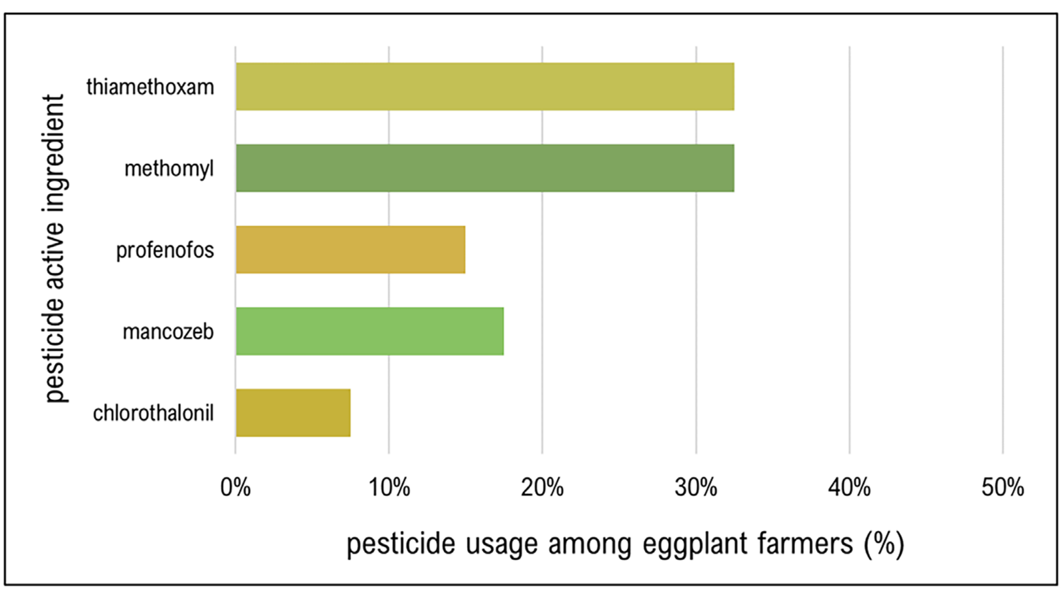

Figure 5. Top registered insecticides and fungicides used by the eggplant farmer cluster in Brgy. San Mateo, Dolores, Quezon, Philippines.

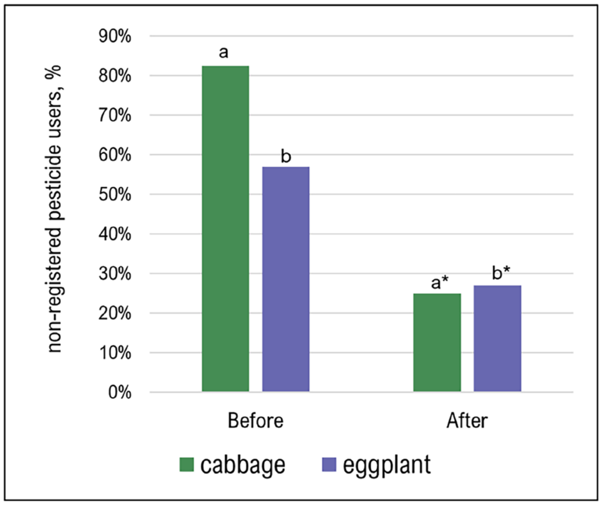

Figure 6. Users of pesticides not registered for cabbage and eggplant before and after the intervention. The * denotes significant differences between the data represented by the same letter ($P < 0.05$). McNemar's test and two-tailed binomial test were used to assess significant differences before and after the intervention for cabbage and eggplant clusters, respectively.

Table 2. List of pesticides not registered for cabbage used by farmers in Lengaoan, Buguias, Benguet, Philippines.

Active ingredient	Toxicity category	No. of users
Lambda-cyhalothrin	II	34
Chlorpyrifos	II	8
Carbaryl	II	3
Methomyl	II	1
Flonicamid	IV	1
Thiamethoxam	IV	2
Imidacloprid + beta-cyfluthrin	II	1
Carbofuran	II	5
Propineb	IV	26

Moreover, the monitoring of the effect of farmers' training on pesticide management was extended to include its outcome on chemical food safety and trading implication. Selected newly harvested cabbage and eggplant were collected and analyzed for residues of organochlorines, organophosphates, and pyrethroids by a multi-residue method using GC-MS. For eggplant, no detectable pesticide residues (< 0.01 mg/kg) were found in 100% (n = 20) of the samples collected. Meanwhile, 80% (n = 20) of the cabbage samples were found to have no detectable pesticide residues, with results below the limit of quantitation (< 0.01 mg/kg). However, four samples were found to contain cypermethrin, profenofos, or chlorpyrifos residues ranging between 0.01–0.08 mg/kg (Table 4).

DISCUSSION

This study explored the impact of farmers' training on the proper pesticide management towards food safety relevant to conventional cabbage and eggplant production. Two farmer clusters consisting of 40 cabbage farmers from Buguias, Benguet, and 37 eggplant farmers from

Table 3. List of pesticides not registered for eggplant used by farmers in San Mateo, Dolores, Quezon, Philippines.

Active ingredient	Toxicity category	No. of users
Carbaryl	II	6
Lambda-cyhalothrin	II	11
Chlorpyrifos + BPMC	II	6
Cypermethrin	IV	6
Chlorpyrifos	II	3
Dinotefuran	IV	4
Imidacloprid + beta-cyfluthrin	II	4
Pyraclostrobin	II	1

Table 4. The concentration of pesticide residues in the positive cabbage samples as analyzed using GC-MS in comparison with the various maximum residue limits (MRLs) set by ASEAN, CODEX, and the EU.

Sample number	Active ingredient	GC-MS result (mg · kg^{-1})	ASEAN MRL[1] (mg · kg^{-1})	CODEX MRL[2] (mg · kg^{-1})	EU MRL[3] (mg · kg^{-1})
5	Profenofos	0.08	–4	–4	0.01
9	Cypermethrin	0.01	1	1	1
13	Chlorpyrifos	0.06	1	1	0.01
16	Cypermethrin	0.01	1	1	1

[1]Association of Southeast Asian Nation (ASEAN) Maximum Residue Limit (https://asean.org/wp-content/uploads/2022/04/Crops-1-DATABASE-ASEAN-MRLs-Oct-2020_public.pdf)
[2]CODEX Alimentarius Commission Maximum Residue Limit (https://www.fao.org/fao-who-codexalimentarius/codex-texts/maximum-residue-limits/en/)
[3]European Union Maximum Residue Limit (https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/products/details/140)
[4]Means no established MRL

Dolores, Quezon were organized. The farmer participants from both clusters were in the middle-aged group and had average educational attainment of high school level. Educational attainment was considered a crucial factor in the farmers' willingness to adopt new techniques and technologies and improve farming practices (Fakkhong and Suwanmaneepong 2017). The result implies that most of the farmer participants had low levels of education. This may be an important factor in the farmers' compliance with proper pesticide practices. Meanwhile, the majority of the cabbage farmers attended training at least once about crop production and crop protection compared to eggplant farmers.

Most of the cabbage and eggplant farmers were using pesticides classified under toxicity Category IV, which are considered relatively safe and there were no farmers using a toxicity Category I pesticide. Pesticides were classified by WHO based on their oral and dermal toxicity. Toxicity Category I is the most dangerous, whereas toxicity Category IV is the least dangerous (WHO 2020). In terms of disease management for eggplant, only a limited number of farmers were using fungicides. Eggplant farmers were observed to be using relatively fewer pesticides for pest and disease control.

Some of the findings were the misuse of pesticide products as determined from both clusters. This is a common concern among the eggplant and cabbage farmers in this study as 52.5 and 87% of them were using non-registered pesticides prior to intervention, respectively. Lambda-cyhalothrin was the most used insecticide not registered for cabbage by the farmer participants. It was also used by most of the cabbage farmers in Dalaguete, Cebu, as reported by Calinawan *et al.* (2017). Moreover, in the study of Davalos *et al.* (2011), pesticides not registered for eggplant used by farmers in Central Luzon accounted for 64% of the total pesticides used in the area. The incorrect pesticides used for both crops have no available information on the recommended dosage, frequency, and PHI among others; therefore, its efficacy and safety cannot be guaranteed. The misuse of pesticides for both cabbage and eggplant may be attributed to the following: lack of awareness of the crop-pest-specific use of pesticides, selection of pesticides based on the recommendation of other farmers and/or retailers, cost of pesticides, or access to pesticides, among others.

Nationally authorized pesticides are the pesticides registered for use in the Philippines with public and occupational health and environmental safety considerations. These pesticides are specifically registered for specific crops. The training particularly strengthened the capacity of farmers to correct pesticide selection. This was evident in the decrease in the number of farmer participants who were using an incorrect pesticide for both crops after the intervention. This means that the training conducted had a significant impact on the reduction and no farmers switched from using correct pesticides in their production to using incorrect pesticides after the training. This positive improvement can be attributed to the intervention provided, which resulted in the farmers' better understanding of the impact of correct pesticide selection on food safety. The farmer participants were introduced to the importance of familiarizing pesticide active ingredients and not only looking at the pesticide brand names for selection. Mengistie *et al.* (2017) reported that smallholder farmers were found to have difficulty reading overly technical information on pesticide labels. To circumvent this concern in our study, sufficient information on pesticide management was given by various experts through straightforward discussions and simple illustrations. Moreover, educational pamphlets were also given to the farmers to serve as their guide on proper pesticide selection and planning. Other topics in the training given emphasized the right timing of pesticide application, compliance with PHIs, and following label recommendations as part of the judicious use of pesticides.

The findings offer compelling support to the recommendations of previous studies that comprehensive interventions such as training and workshops are positively associated with safe and correct pesticide management (Macfarlane *et al.* 2008; Jors *et al.* 2014; Damalas and Koutroubas 2017; Gautam *et al.* 2017; Jallow *et al.* 2017). In the study of Chen *et al.* (2013), the negative effects of the overapplication of pesticides by farmers were lessened through knowledge improvement on pest management. This resulted in a 10–15% reduction in the overall usage of pesticides. The training was linked to farmers' increased pesticide knowledge and elevated safety behaviors as reported by Damalas and Koutroubas (2017). Moreover, Schreinemachers *et al.* (2012) described that farmers interviewed in Thailand were found to be knowledgeable about minimizing pesticide exposure during preparation and application. They were also interested to know the risks of pesticides and as such, the authors suggested that generating more awareness about the risks of pesticide residues to the consumers and the environment would improve the farmers' knowledge of the critical control points. In the current study, although there were still farmers who used an incorrect pesticide in their production, the reduction in the users of incorrect pesticides for both crops was a good indication of the positive attitude of the respondents toward the correct pesticide management. The concern about pesticide misuse was still acknowledged and brought up in a farmers' meeting so that this malpractice is corrected.

Meanwhile, newly harvested eggplant samples analyzed for residues of organochlorines, organophosphates, and pyrethroids yielded no detectable residues. This means that all the eggplant samples tested complied with the CODEX and ASEAN MRLs for the listed pesticides. However, additional analyses that cover other pesticide groups were not done. In comparison with the study done by Lu in 2011, one eggplant sample from a farm in Sta. Maria, Pangasinan was detected with chlorpyrifos residues (0.03 mg/kg) exceeding the CODEX MRL, whereas three samples contained cypermethrin which is not registered for eggplant (n = 20). Meanwhile, the monitoring data of Plant Product Safety and Services of BPI-NPAL showed that cypermethrin and profenofos were the most frequently detected pesticide residues in eggplant samples taken across the different regions in the Philippines from 2013–2015 (Magcale-Macandog *et al.* 2016). No exceedances of profenofos MRL in eggplant were recorded in this study.

For the cabbage samples, four were found to contain cypermethrin, profenofos, or chlorpyrifos residues ranging between 0.01–0.08 mg/kg. The residue values were compared to various existing MRLs. The chlorpyrifos residue (0.06 mg/kg) detected in one cabbage sample was a result of pesticide misuse as chlorpyrifos is not a registered pesticide for cabbage. It was an oversight of one farmer participant who mistakenly applied the insecticide. In the study of Lu (2015), harvested cabbage from Benguet was found to contain the highest level of pesticide residues, followed by celery and broccoli. Profenofos was the most detected pesticide residue in cabbage (Lu 2015). This may be attributed to the monocropping system for cabbage in large agricultural areas in Buguias, which leads to an increase in pest and disease incidence, resulting in more frequent pesticide application (Cai *et al.* 2011; Luchen 2012).

All positive cabbage samples have residues lower than the CODEX and ASEAN MRLs except for profenofos with no existing MRL for cabbage (Table 3). All the samples positive for cypermethrin (two out of four) will still be acceptable for export to EU countries, whereas samples positive for profenofos or chlorpyrifos (two out of four) will not be accepted. Overall, 19 out of 20 (95%) cabbage samples complied with the CODEX and ASEAN MRLs, and 18 out of 20 (90%) complied with the EU MRLs. Compliance with MRLs means that farmers are assured of following proper pesticide application and residues are far from food safety hazards (Winter and Jara 2015; EU n/d; FAO/WHO n/d).

This study showed that the farmers' training has a positive role in the conduct of proper pesticide management. The results suggested that through training, there was a significant reduction in the usage of pesticides not registered for cabbage and eggplant. The training improved the knowledge of farmers about the correct selection of pesticides to be used for specific pests in vegetable production. They were also reminded of the proper usage of pesticides through label interpretation, frequency of application, and the importance of PHI. This increase in knowledge was accompanied by improved understanding of food safety. This was demonstrated through the results of the monitoring and pesticide residue analysis. Cabbage and eggplant samples were compliant with the existing CODEX and ASEAN MRLs for the tested pesticides, proving that conventional production can still be safe with proper pesticide management and considerations of GAP. Vegetables produced will not result in human health risks when consumed; thus, they can be regarded as safe. Moreover, the set of practices taught in the training can be continuously employed in the farmer clusters with an internal monitoring protocol, wherein farmer leaders can conduct monitoring of cluster members to ensure proper pesticide management. This will establish an internal control system (ICS), which if employed with consistency, can serve as a competitive advantage and be preferred by consumers – especially health-conscious consumers. This was emphasized in the farmer meetings conducted.

CONCLUSION

The cabbage and eggplant farmers' training improved their pesticide management practices and technical knowledge in the production of safe vegetables. The farmers' use of pesticides not registered for both crops was reduced substantially and residue analysis for organochlorines, organophosphates, and pyrethroids using GC-MS confirmed that all eggplant and cabbage samples are compliant with the CODEX and ASEAN MRLs for the listed pesticide groups. The training and monitoring demonstrated that when GAP-based pesticide control practices are followed, conventional cabbage and eggplant production produces eggplant and cabbage that are compliant with international regulatory limits for pesticide residues that can be equated to assurance of food safety. These set of practices can then be sustained and improved through time by implementing an ICS in the farmer clusters.

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