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Application of pesticide in pest management: The case of lowland vegetable growers

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Abstract

This study investigates pest management practices among lowland farmers on growing leafy and fruit vegetables, particularly focusing on the pesticide usage in controlling pest. In Malaysia, vegetable productions in lowland areas are to some extent really important as in the highland areas due to the wide marketing channel, from local till traded across border. Yet, the ignorance of vegetables safety regarding the appropriate of pesticide usage by farmers was undeniable, as the market demands only products with good extrinsic quality. Thus a survey was conducted among of 85 of lowland vegetable farmers to get information on their pest management practices in farms. Result showed that the pesticide application by farmers on vegetables crops still indicated a calendar spraying practices. In most cases, farmers tend to harvest the vegetable products shortly after a few days of last pesticide spraying. In order to enhance the food safety control starting from the primary production, extensive monitoring of the current pesticide usage by farmers in vegetable productions is vital to provide an updated data on the food safety risk regarding to the pesticide residues. Therefore, the thrust of this paper was to get a better understanding on the level of safe pesticide usage among vegetables farmers especially in areas of growing vegetables productions.

Introduction

Vegetable is a component in healthy diet that needs to be taken by human daily intake and it is essential to help disease prevention (WHO, 2005). Along with the rapid growing population, the vegetable productions in developing countries are somewhat important to support not only for local consumption, but also to meet demand in developed countries by providing exotic and out-of-season vegetables products. It is undeniable that the demand for supplies year-round of vegetables in nationwide could not be met without the intensive pest management (Dinham, 2003). Therefore, the effective pest management is greatly associated with the chemical pesticide use as it is an important tool to contribute high yields by controlling pests and diseases in farm productions. In response to reduce crop losses by the pest attacks, farmers tend to use many range of pesticide types, including insecticides, fungicides, herbicides and others in order to generate plentiful of yield and income (Jinius *et al*., 2001). However, the inappropriate use of chemical pesticide by farmers has been greatly discussed worldwide (Ngowi *et al*., 2007; Williamson *et al*., 2008; Xu *et al*., 2008; Zhou and Jin, 2009). Few studies have mentioned that farmers in low-income countries are said to use much smaller quantities of pesticide than farmers in high-income countries and their usage leads to more vulnerable risk to be arisen. In vice versa, developed countries tend to go in direction of fewer chemical applications and use pesticide that is more environmentally friendly (Carvalho, 2006; Panuwet *et al*., 2008). But, updated data has showed that the pesticide use per hectare by high-income countries was significantly increased in recent years. In the group of upper middle-income countries, including Malaysia, Argentina, Brazil, and South Africa Uruguay, no positive results in reducing pesticide use was obtained (Schreinemachers and Tipraqsa, 2012).

There are many studies of pest management practices by farmers have been carried by previous researchers, but mainly focused on the highland farming area and pest control for specific types of vegetable (Mazlan and Mumford, 2005; Badenes-Perez and Shelton, 2006; Grzywacz *et al*., 2010). These studies have showed quite similar trends in pest management practices particularly on pesticide usage by vegetables farmers. Xu *et al*. (2008) showed that more than 50% of farmers attempted to control the

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pest outbreak by increasing the frequency and dosage of pesticides, as well as to combine them in a tank mixture when pest organism reluctant to respond to single kind of pesticide. Farmers also tend to ignore the recommended pre-harvest interval written on the label in order to keep the good appearance of vegetable products. It is a current practice for farmers to apply the pesticides on their crops in the afternoon and harvest the vegetable products by the next morning without any concern on hazardous of pesticide residue due to the economic advantage. In calendar spraying method, farmers keep applying pesticide at set interval days even though there is no sign of pest outbreak in effort to avoid any marks of pest damage that can lower the products' price (Dinham, 2003). While in tropical country such as Malaysia, farmers usually keep changing their spraying frequency depending on the weather. The spraying frequency is more rapid in the wet season due to quick washed off of the pesticide (Mazlan and Mumford, 2005). Thus regarding to the potential risk of pesticide to consumers, as well as on the environment and towards pest resistance, there is growing concern to control the food safety risk in vegetable productions (Cengiz *et al*., 2007; Grzywacz *et al*., 2010; Thuy *et al.*, 2012).

Organochlorine insecticide (OC), such as DDT, hexachlorocyclohexane (HCH), aldrin and dieldrin, has been said to be extensively used by Asian farmers because of their broad spectrum activity and low cost (Gupta, 2004). Due to its characteristics of carcinogenic and as endocrine disruptors (Thomas *et al*., 1998), the usages of these pesticides were prohibited around late 1990s (Zakaria *et al*., 2003). However, their resistance to degradation has been proven and there were positive results in their existence obtained from recent studies. It has been suggested that one of the major source of contamination of OC insecticide is due to the agricultural activities (Sudaryanto *et al*., 2005; Leong *et al.*, 2007). Apart from OC insecticide, organophosphate insecticides are also extensively used by farmers due to their broad spectrum activity. Yet, they are much more toxic compared to the others even though their degradation in environment are rapid and tend to cause contamination of pesticide residue in food as well as in environment (Chambers *et al*., 2001; Bempah *et al*., 2011). Pesticide residues that remain on agricultural commodities are known to be carcinogenic/toxic and it could lead to health risk especially when commodities are freshly consumed (Zawiyah *et al*., 2007). Therefore, maximum concentration of pesticide residues (expressed as mg/kg) which legally permitted to present in food commodities, recommended by the Codex Alimentarius Commission (Codex) has been established and referred as maximum residues level (MRL). In Malaysia, under the Regulation 41 of Food Regulations 1985, the MRL of pesticide residues for specific commodities are well prescribed in Sixteenth Schedule (MOH, 2014). As some of them may quickly disappear or break down into harmless substances, majorly parts of the pesticide may persist and leave unsafe residues in food (Dinham, 2003). It must be noted that the MRLs did not indicated the safe level of pesticide residues to be exposed to human, but to resemble the Good Agriculture Practice (GAP) conducted by farmers during the farm productions.

Due to the increasing demand by local and export market, the vegetable production in Malaysia is not only focusing on the highland areas, but also through the growing production in lowland areas. The importance of lowland vegetable production as a main source of vegetable products has been shown in the recent statistic of total vegetable productions (DOA, 2014). Despite the needs to focus on the growth of vegetable productivity, it is a must to look at the flow of pesticide usage in the vegetable productions due to the pesticide residue risk especially when consumer consumed the raw products. Therefore, rapid monitoring data on pesticide usage in developing countries were developed to enhance the effectiveness on the food safety policies (Leong *et al*., 2007). As a means to enhance good agricultural practices and safe use of pesticide by farmers in the areas of growing vegetable productions, a study was carried out in the lowland vegetable areas of Peninsular Malaysia in 2013. The purpose of this research is to provide comprehensive information on farm pest management practices by the lowland vegetables farmers. This information needed to evaluate the potential food risk as a result of pesticide usage in Malaysian lowland farming system and to provide a better insight on potential approaches that can be taken to reduce pesticide residues incidence in vegetables products.

Materials and Methods

The study was conducted between April and September 2013. It consisted of interviews with farmers and farm workers where leafy and fruit vegetables were mostly cultivated by using farm inputs, particularly pesticides. A total of 85 farmers were interviewed whom were from Johor, Selangor, Pahang, Negeri Sembilan, and Perak states. The sites were selected based on the ease of accessibility, cooperation from the Department of Agriculture (DOA) in each states and willingness of farmers or

Table 1. Socio-demographic profile

Profile	Frequency (n= 85)	Percentage (%)
Race		
Malay	40	47.1
Chinese	38	44.7
Indian	4	4.7
Others: Indigenous people	3	3.5
Age (years)		
≤29	7	8.2
30-39	18	21.2
40-49	29	34.1
50-59	22	25.9
≥60	9	10.6
Experience (years)		
≤5	29	34.1
6-10	13	15.3
11-15	9	10.6
≥16	34	40.0
Education attainment		
No formal education	4	4.7
Primary	31	36.5
Secondary	34	40.0
College/University	16	18.8
Farm area (acre)		
≤1.0	7	8.2
1.1-5.0	38	44.7
5.1-9.0	15	17.6
9.1-13.0	12	14.1
≥13.0	13	15.3

farm workers to participate in the interview. The survey was conducted through face-to-face interviews with farmers or farm workers using a structured questionnaire, which comprised open-ended, closed-ended and Likert scale questions. The interviews were carried out in the appropriate local languages (Bahasa Melayu and Mandarin). Farmers were asked about their socio-demographic information, pest control methods, types of insecticides and fungicides used to control pests, methods in pesticide application, frequency of pesticide spraying and pre-harvest intervals. The data were analyzed using several statistical analyses. Descriptive analysis was used to describe farmers' socio-demographic background and general pest management practices. Chi-square analysis was carried out to investigate the relationship between pest control methods and farmers' farm area. Apart from descriptive and chi-square analysis, factor analysis was conducted to analyse the factors that influence farmer's pest management practices in their farm. Factor analysis was employed to reduce the number of variables and group them according to their common underlying characteristics. The Kaiser-Meyer-Olkin (KMO) statistic with value equal to 0.60 or higher was used to determine whether the variables accepted to be conducted in the factor analysis. Factors with eigenvalues greater than 1 were considered significant for factor analysis. Factor loading represented the correlation between the variables and the factor. The cut-off point of factor loading used was greater than 0.50. Each factors extracted in factor analysis were then tested by reliability analysis. Cronbach's alpha coefficient of more than 0.6 was considered to be acceptable while value with greater than 0.7 was reliable for the study (Nunnally, 1978).

Results and Discussion

Farmers' background

Table 1 shows demographic profile of farmers in the study. A total of 85 lowland vegetable farmers were interviewed, with majority of the farmers were Malay (47.1%), then followed by Chinese (44.7%), Indian (4.7%) and a few of indigenous people (3.5%). Result showed that most of the farmers who dominated vegetable farming in the study were aged ranging from 40 to 49 years old (34.1%). Only several farmers were found had an age of 60 years old and above (10.6%). Farmers with an age of 29 years old and below (8.2%) showed the lowest percentage in farming involvement, yet, it was a good sign that young generation having desire to be involved in vegetable farming. The result indicated that majority of the lowland farmers in the study were having experience in vegetable farming with more than 16 years (40%). There was also new entrance farmers found in the study, with 1 to 5 years of experience (34.1%). Those farmers who are newly involved were either retired from government/public sectors or young farmers who inherited their family business in vegetable productions. The rest were having experience ranging between 6 to 10 years (15.3%) and 11 to 15 years (10.6%). For the education attainment, the most education level of the farmers was secondary education (40%), followed by primary education (36.5%). Several farmers had higher education levels (college/university), which indicated by 18.8% of the farmers. Only a few farmers (4.7%) were found have no formal education.

The farming system sampled in the lowland vegetable areas typically consists of smallholder farmers with farm areas ranging from 1.1 to 5.0 acre, used by 38 farmers (44.7%). However, there were also a quite number of farmers who growing their crops on farm areas of more than 5.0 acre (approximately ≥ 2ha), which found to be ranged from 5.1 to 9.0 acre (17.6%), 9.1 to 13.0 acre (14.1%) and also 13.1 acre and above (15.3%). The smallest farm areas found to be used by farmers was 1.0 acre and below, but by only 7 farmers (8.2%). Within the vegetable farming system sampled in lowland area of Malaysia, there were five types of land status that was found: own land, temporary ownership license (TOL), lease land, Malaysian Permanent Food Park Program (MPFP) area and illegal land. Temporary ownership license (TOL) land tenure is referring to land area owned by local government, which farmers permitted to hold the land for 1 to 15 years with certain nominal fees, particularly for farming activities (Mazlan and Mumford, 2005). While under

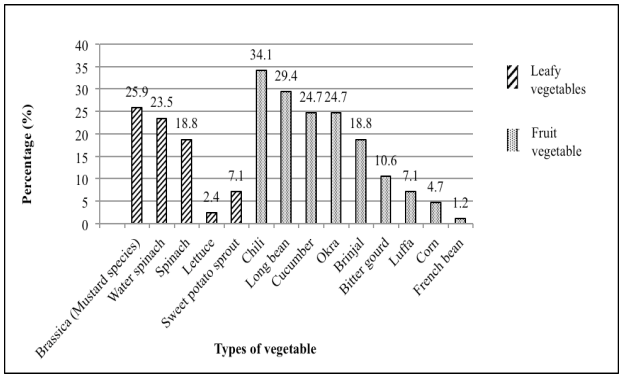

Figure 1. Types of vegetables cultivated by lowland farmers

MPFP area, it was design by local government with an aim to produce large scale of farming area and encourage farmers to participate by providing lot to rent. Study revealed that vegetables farmers in Malaysia particularly in the lowland areas commonly cultivate many types of vegetables in every season of planting due to economic advantages. The types of vegetables planted in each season can be varied depending on the demand and market price. Figure 1 shows the percentage of both leafy and fruit vegetable cultivated by sampled farmers.

Insect pest and diseases

Farmers were asked on the insect pests and disease attacks on the crops. Insect pests mentioned by the farmers interviewed included diamondback moth *(Plutella xylostella)*, cutworm *(Agrotis ipsilan)*; army worm *(Spodoptera litura)*, shoot borer *(Leucinodes orbonalis)*, tomato fruit borer *(Helicoverpa armigera),* Bean pod borer *(Maruca testulalis)*, Aphids (*Aphis* spp.) and thrips (*Thrips* spp). For diseases, farmers mentioned on the leaf spot (multi-host), rots (multi-host), downy mildew (*Perenospora* sp.) and powdery mildew (*Oidium* sp.).

Pest management practices in vegetable production

Table 2 shows pest management practices of lowland vegetables farmers in the study. Result obtained from interviews in this study showed that the usage of synthetic pesticides by farmers was the most common crop protection strategy to control plant disease and insect pests (97.6%). The rest of two farmers interviewed were solely depending on organic farming cultural practices in producing vegetable productions though their farms location was nearby with whom greatly depending on inorganic pesticide usage. It was found that cultural control practices were the second choices of interest among farmers to be used in pest control. Nearly half of the farmers (48.2%) responded that they used crop rotation method in order to minimize the pest infestations in their farm. About 15 farmers (17.6%) stated that they were conducted pest monitoring weekly. Pest monitoring is somewhat vital to let them acknowledge the density of insect pests and observe the type of diseases attacked on the crops. There were only a few farmers mentioned of biopesticide usage in their pest management practices (8.2%). It should also be noted that there were poor usage of sticky trap (9.4%) and pheromone trap (7.1%) among farmers.

Majority of the reason to apply pesticide by farmers was due to the application of calendar spray method (76.5%), followed by the presenting of pest (36.5%) and increasing number of pest (16.5%). Every reason to apply pesticide on crops made by farmers may affect the frequency of pesticide applications depending on the needs. Farmers were then asked on their application of pesticide mixture when preparing pesticide solution. A total of 88.2% farmers responded that pesticide mixture is their common practice in pesticide application, where a combination of 3-4 types of pesticides is most common (69.3%). Some of the farmers preferred to use only two types of pesticides in a combination (30.7%). The types of pesticide they combined in pesticide tanks may be different in each application depending on the needs. Majority of the farmers (88%) choose to combine insecticide with fungicide in a mixture. There were also farmers who choose to mix insecticide with insecticide (17.3%) and fungicide with herbicide (2.7%). There were four main reasons listed by farmers who choose to use pesticide mixture methods which are; time saving (60%), reducing labour cost (48%), greater effect in controlling pests (33.3%) and be able to control many types of pests (22.7%). Only 11.8% of the sampled farmers did not use the pesticide combination.

For the pesticide spraying frequency, a total of 47 farmers (55.3%) indicated that they applied pesticide on crops once a week, with every 5-7 days of each application. A more frequent pesticide application frequency was used by 30 farmers (35.3%), where they usually applied pesticide in every four days and below for each application. The remaining farmers applied pesticide once in every eight days and above (9.4%). Result showed that the frequency of pesticide spraying practicing by farmers still indicated a calendar spray pattern, in which according to Ngowi *et al.* (2007), farmers commonly keep applying pesticide on crops without any consideration of incidence or level of pest attack. A term of pre-harvest interval (PHI), which refers to a period between the last pesticide application and harvesting time of treated crops, also is an important element in determining farmers' pest management

Table 2. Farmers' pest management practices

Practices	Frequency (n= 85)	Percentage (%)
Pest management method		
Synthetic pesticide	83	97.6
Crop rotation	41	48.2
Pest monitoring	15	17.6
Biopesticide	7	8.2
Sticky trap	8	9.4
Pheromone trap	6	7.1
Reason to apply pesticide		
Follow calendar spray method	65	76.5
Presents of pest	31	36.5
Increasing number of pest	14	16.5
Application of pesticide mixture		
Yes	75	88.2
No	75	11.8
Number of pesticide mixture		
2 types	23	30.7
3-4 types	52	69.3
Type of pesticide mixture		
Insecticide + insecticide	13	17.3
Insecticide + fungicide	66	88
Fungicide + herbicide	2	2.7
Reasons to use pesticide mixture method		
Time saving	45	60
Greater effect	25	33.3
Reduce labour cost	36	48
Able to control many pest	17	22.7
Pesticide spraying frequency		
4 days and below	30	35.3
5-7 days	47	55.3
8 days and above	8	9.4
Pre-harvest interval (PHI)		
3 days and below	50	58.8
4-7 days	25	29.4
8 days and above	10	11.8

practices. The recommendation PHI stated in most of the pesticide products are between 7-14 days. Even though the common pesticide spraying frequency stated by farmers was between five to seven days for each application, but the PHI practiced by 50 farmers (58.8%) in the study was as short as three days and below. Only 25 farmers (29.4%) choose to practice PHI between the duration of four to seven days. The rest of 10 farmers (11.8%) indicated that they were practicing a PHI of eight days and above.

It can be concluded from the data in Table 2 that vegetables farmers in the lowland areas were mainly relied on the pesticide usage in combating insect pests and diseases attacked. Only a few farmers were found to practice a combination of pesticide usage with the other IPM approaches. The component of IPM such as biopesticide, sticky trap and pheromone traps, area among the least to be practiced by farmers in their farm production. This is along with the wide reports on the dependent of synthetic pesticide usage by farmers in horticulture crops productions, either by the local studies (Jinius *et al*., 2001; Mazlan and Mumford, 2005) or by the international researchers (Sibanda *et al*., 2000; Badenez-Perez and Shelton, 2006). Despite relying on synthetic pesticide usage, it has been highlighted from these studies that farmers starting to adopt integrated pest management (IPM) practices such as the usage of cultural methods, pheromone trap, biopesticides and other non-chemical related practices in their vegetables farm productions. Earlier studies also had showed the necessity to apply crop rotation since the continuous planting of the same crops will lead to continuous attacks of the same species of insect pests. Problem arises when farmers keep switching to new insecticides when insecticide resistance of pests developed. Due to the emerging of insecticide resistance in crucifers productions in Southeast Asia, which including Malaysia, the use of crop rotation is one of the practices that has been introduced to against *Plutella xylostella* (Talekar and Shelton, 1993).

In the study, it was found that Bacillus thuringiensis (Bt) based products were one of the commercial biopesticide that farmers commonly applied to control insect pests. This product has known to be contained bacterium with toxicity strain that capable to kill specific lepidopteran larvae without destroying beneficial insects (Sibanda *et al*., 2000). According to Kamarulzaman *et al.* (2012), there were of great challenges in promoting biopesticides usage among vegetable farmers though it has been proven to be able in controlling pest. Unfortunately, the lack of understanding on the benefits of biopesticides and less promotion towards the usage, are the common reasons for the less use of this alternative product than synthetic pesticides in vegetable productions. Therefore, it was not surprisingly found that only few farmers in the study preferred to apply biopesticide though it has safety advantages to synthetic pesticides. On the top of that, both sticky trap and pheromone are vital to provide indication to farmers on the existence of insect pests on crops. Farmers only need to apply the insecticide when the insect pest catches exceed certain level, which can lead to plant damage (Cameron *et al*., 2009). But the result obtained in the study is line with the finding stated by Mazlan and Mumford (2009) in which IPM practices were not being the first place to be applied as farmers rely more on the synthetic pesticides usage.

In pesticide spraying, the reason to apply pesticide by farmers was largely due to the application of calendar spray methods. Result suggested that farmers tend to ignore the pesticide risk because they keep applying the pesticide within a certain period, even though there is no sign of any pest attacks on the crops. A calendar spray method is a practice that remarkable among farmers in which pesticides usually being applied once in every three to five days (Amit *et al.*, 2004). However, the disadvantage of calendar spray method is it encourages farmers to keep spraying without any consideration of incidence or level of pest attack because it has been scheduled (Ngowi *et al.*, 2007). Badenez-Perez and Shelton (2006) emphasized in their study on pest management practices among crucifer growers that farmers may apply pesticides based on solely decision basis or a combination of presence of pests and a calendar spraying method. It was believed on

the previous study that those farmers typically start to use scheduled method after noticing pests on the crops.

Farmers interviewed were asked whether there is a repetition of pesticide application after raining. In most cases, farmers stated that there was no second pesticide application was made within the same day even though it was rained heavily after the first pesticide application on the crops. Instead, the alternative was to increase the frequency of pesticide spraying by having shorter interval (days) between each pesticide application on the crops. These finding was consistent with those reported earlier by Mazlan and Mumford (2005) that farmers applying pesticide on the crops with more frequent in wet season than dry season due to quick washed off of pesticides. Thus it requires more effort to control the pest infestation. Among the decision basis, the best to follow is to apply pesticide when there is increasing number of pest on the crops as it can prevent the excessive pesticide usage among farmers. According to the IPM concept, is it important to be noted that the usage of pesticide is the last resort of choices to be taken if another alternatives are not effectives to against pest infestation on the crops (Thuy *et al*., 2012). However, the number of farmers who found practicing IPM approaches in the study was low.

Result indicated that most of the farmers prefer to use the pesticide mixture method in preparing pesticide solution. The types of pesticide to be mixed may be varying in each application due to the different types of pest attacks. Farmers responded that they may change the type of pesticide to be mixed or applied if the specific pest reluctant to respond on the pesticide spraying before. In most cases, farmers claimed that the selection of pesticide to be used in pesticide mixture method was based on their own experience in pesticide usage. Pesticide selling agent also found to be played an important role in determining the pattern of pesticide mixture practiced by farmers. According to Lim (1990), pesticide mixtures are widely used by farmers and known as "cocktail". Farmers always believe that the use of pesticide mixture method can give a greater effect in controlling pest. As shown by the result, more than half of the farmers in the study prefer to apply pesticide mixture method when preparing pesticide solution. However, the fact is, chemical reactions from the mixing can change the properties of pesticide; either becomes more toxic or less efficient (Thuy *et al*., 2012).

In pesticide spraying frequency, the present data indicate that farmers applied pesticide once or twice in a week, with every five to seven days of each pesticide application on crops. Farmers' response to pest attacks may different depending on the weather changes. During rainy seasons, the period between each pesticide spraying was shorter due to the quick washed off of pesticide on the crops. Though farmers responded that they were aware on the implication of excessive pesticide usage regarding the pesticide residue in the vegetables, however, it was still lacking of courage among farmers to change their pesticide usage behaviors. Meanwhile the result of PHI demonstrates that farmers usually ignore the recommended period of PHI (seven days and above). It was also found that some of the farmers keep spraying pesticide on their crops even when nearly to the harvesting time in order to avoid pest attacks. By lowering the pesticide concentration in a recommended pesticide solution volume, farmers in the study believed that it was an alternative to reduce the risk of pesticide residue over the maximum residue limits (MRL) in the harvested vegetables.

High consumption of vegetable in human dietary is very encouraging because of the ability of preventing disease and the essential nutrients contained in the vegetable itself (Bogers *et al*., 2004). Still, the function of pesticide in vegetable productions to control undesired organisms that affecting produce quality cannot be denied (Claeys *et al.*, 2011). Thus it is greatly important for farmers to follow the recommended PHI of pesticide due to the possibility of pesticide residue presented in the vegetable commodities and its risk to consumer especially when they consumed it raw (Claeys *et al*., 2011). It must be denoted that the violation of MRLs was a sign of noncompliant of PHI or in the other terms, farmers did not apply the Good Agriculture Practice (GAP) in their farm productions. As food can be the main exposure route to pesticide residue, the probable health risk among consumer from their daily vegetable consumption can be ranged from short-term impacts such as headache and nausea to chronic impacts like cancer and endocrine disruption (Berrada *et al.*, 2010). Due to the given potential risks to public health, it is therefore, constant monitoring program especially on the proper use of pesticide in agriculture is very essential to ensure GAP among farmers are being performed (Claeys *et al.*, 2012).

Pest control methods and farmers' farm areas

Previous finding by Badenes-Perez and Shelton (2006) showed there was a positive relationship between the numbers of pesticide application with total area of land cultivated by farmers, and the number of crop losses due to the insect pests decrease with increasing of the number of pesticide application. Therefore, in this study, Chi-square analysis was

Table 3. Relationship between farmers' farm area and their methods on pest control

Variable	*Chi-square*	*df*	*Significant*	*Decision*
Synthetic pesticide	9.558	4	0.049**	Reject H_o
Pest monitoring	5.946	4	0.203	Fail to reject H_o
Sticky trap	5.965	4	0.202	Fail to reject H_o
Pheromone	2.392	4	0.664	Fail to reject H_o
Biopesticide	2.897	4	0.574	Fail to reject H_o
Crop rotation	4.434	4	0.350	Fail to reject H_o

Notes:** Significant at 5% level of significance

carried out to investigate the relationship between farmers' farm area and their methods on pest control. The following were hypotheses for the Chi-square analysis:-

Ho: There is no significant relationship between farmers' farm area and their methods on pest control.

Ha: There is a significant relationship between farmers' farm area and their methods on pest control.

Result in Table 3 showed that there was a significant relationship between farmers' farm area and chemical pesticide application at 5% level of significance. The result indicated that there was of great tendency to have a frequent spray at the larger farm. It has been reported that the large commercial-scale system of vegetable farms often to utilize high level of external inputs, including pesticide (Jinius *et al.*, 2001). However, there was no significant relationship between farmers' farm area and the usage of IPM components on pest control such as pest monitoring, sticky trap, pheromone, biopesticide, and crop rotation. This can be explained by farmers' knowledge and awareness on the importance of IPM components in reducing pesticide usage. Farmers who does not have fully understanding on the pesticide risk tend to solely depend on the synthetic pesticide in combating pest attack and crop diseases. According to Hashemi *et al.* (2008), training on the alternatives to pesticide for farmers is perquisite to improve the safe use of pesticide by encourage farmers to implement IPM component in their farm productions.

Factors that influence farmers' pest management practices

Based on Kaiser-Meyer-Olkin (KMO) test, the result revealed that the sampling adequacy was 65.3% and it is acceptable for conducting the factor analysis. The Bartlett's test of sphericity indicated that the overall matrix was not identify matrix and that it is significant at 0.000 probability level (Approx. Chi-Square= 801.672, df= 105). There were five factors discovered by the principle component analysis (PCA), which collectively explained over 68.65% of the total variance (Table 4). Factor loading represents the correlation coefficients of each item with the factor. It was suggested that the strength of correlation of each item to a factor is greater when the scoring is nearly to 1.0 (Leech *et al*., 2005). The five factors were renamed based on common characteristics in each statement. The factors that influence farmers' pest management practices are renamed as 'knowledge', 'awareness', 'experience', 'frequency of spraying', and 'types of pesticide' (Table 4).

In farmer's pest management practices, Factor 1 (knowledge) consisted of three items with Eigenvalue of 2.480 described that farmers must have adequate information on the suitable methods to be used in their pest control, either by using synthetic pesticide or IPM methods. Apart from knowledge, Factor 2 (awareness) consisted of three items with Eigenvalue of 2.181, which explained that farmers needed to have awareness on the risk that can be emerged due to heavy pesticide usage as of the great possibility on environmental pollution and pesticide resistance. While factor 3 (experience), which consisted of two items with Eigenvalue of 1.987 indicated that farmers' experience would lead to determine the pattern on their pesticide usage on the farm. Factor 4 (frequency of spraying) which consisted of two items with Eigenvalue of 1.887 explained the reason of farmers to keep spraying pesticide on their farm was to avoid the pest infestation and allowed them to have good quality products in terms of extrinsic quality. Meanwhile, the last factor, Factor 5 (types of pesticide) which consisted of two items with Eigenvalue of 1.763 described on the types of pesticide used by farmers, in which both registered and illegal pesticides were available in the market and it has been used to control pest.

The eigenvalues showed on the total variance explained by each factor. Result showed that the five factors have eigenvalues greater than 1.0, which indicated that the factor explains more information than a single item would have explained. For the Cronbach's Alpha, it was computed by the reliability test to shows the internal consistency of a multiple item scale. Alpha for the 'Quality' and 'Awareness' (>0.7) shows that the items form a scale that has reasonable internal consistency, while alpha for the 'Knowledge' (>0.8) indicated good internal consistency. However, factor 'Chosen pesticide' and 'Type of pesticide' with the alpha >0.6 indicated that the items form a scale

Table 4. Summary of factor loadings on farmer's pest management practices

Items	*Factor Loading*				
Factor 1: Knowledge					
I always seek advice from agricultural extension on the suitable methods to use in pest management practices.	0.882				
I am confident with the guidance given by agriculture extensions	0.863				
The promotion of IPM approaches had encouraged me to practices IPM methods in pest management practices.	0.675				
Factor 2: Awareness					
I use IPM methods due to insect resistance on insecticide		0.822			
I use IPM methods in pest management practices to reduce environmental pollution.		0.806			
The application of IPM methods on pest control can reduce the pesticide usage		0.685			
Factor 3: Experience					
I choose pesticide with complete label because it is easier to use			0.817		
I choose the pesticide to use in pest control based on my experience.			0.787		
Factor 4: Frequency of spraying					
I need to keep applying pesticide on my crops to get good quality of vegetables products.				0.890	
Pesticide spraying must be applied frequently in order to avoid pest infestation				0.853	
Factor 5: Types of pesticide					
I am aware that both registered and illegal pesticides are available in market.					0.755
I use methods of pest control that do not cause harm to other lives in farm surrounding.					0.663
Eigenvalues	2.480	2.181	1.987	1.887	1.763
% of variance explained	16.534	14.540	13.248	12.577	11.753
Cumulative % variance explained	16.534	31.074	44.323	56.899	68.652
Cronbach's alpha	0.820	0.703	0.656	0.775	0.608

with minimally adequate reliability.

Conclusion

In terms of quality vegetables, study found that farmers may refer it as good appearance of products, but not on the consideration of the safety value of the products itself especially during the farm productions. This can prove by the usage pattern of pesticide by farmers while handling pest problem in their farm. Farmers usually neglect on the pesticide spray frequency and pre-harvest interval (PHI) that they need to follow when applying pesticide on the crops, due to keep the economic value of vegetable commodities. Thus it was an enormous challenge for both government and the industry players to promote a sustainable agriculture practices due to the lack of awareness on the food risk among farmers. Effort in reducing the use of pesticide for safer food productions must be taken not only by the government, but the responsibility also must be played by the industry players such as wholesalers and retailers. Apart from performing extensive pesticide residue monitoring at different stages in vegetable productions, conducting by Department of Agriculture (DOA) and Food Safety and Quality Division (FSQD), under the Ministry of Health, extensive promotions toward the application of IPM approaches must be developed as it is more environmental friendly and effective to control pest.

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