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Perceptions and practices of pesticides safety measures of rice farmers in the central region of Vietnam

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Abstract

The use of pesticides is increasing rapidly and the pesticide use crisis is badly damaging the environment, the economy, and public health in Vietnam. However, the country is yet to become successful in reducing pesticide use mostly because of policy implementation and inadequate understanding of farmers. This study examined and discussed the perceptions and safety level of using pesticides by applying a widely used index of 39 indicators equivalent to 39 safety measures grouped into four categories to assess the safety behaviour of rice farmers in the central region of Vietnam. A field survey of 323 rice farmers and 12 local leaders was conducted in Quang Tri and Thua Thien Hue provinces. The result revealed that there exists a significant difference ($p < 0.001$) between the perception and practices of pesticide safety measures of rice farmers in the study area. The overall score appears relatively high (4.09 and 3.89 out of 5.0 for perception and practices, respectively), indicating that farmers believe what they are doing is safe, though there are significant variations among the categories and among farmers in practising pesticide safety measures. Regarding the farmers' safety level, it was observed that there are still 18.1 % and 34.4 % of rice farmers are under unsafe and potentially unsafe conditions, respectively. Hence, an effective extension and communication program regarding the management and safety use of pesticides is the most vital policy solution to protect the rice farmers from potential health risks and ensure the sustainability of agriculture.

Keywords: rice farming, agrochemicals, plant protection, safety measures

1 Introduction

Pesticides are widely used and play an important role in modern farming to ensure agricultural productivity and food supplies. Various types of agrochemicals including fungicides, herbicides, insecticides, rodenticides, and plant growth regulators are being used. These agrochemicals are used by farmers to protect crops from harmful insects, weeds, crop diseases (caused by fungi, bacteria and viruses), nematodes, snails, slugs, rodents, rats, and birds that consume enormous quantities of seed and grain (Salaza & Rand., 2020). However, the continuous reliance on pesticides in agriculture poses serious threats to both the ecosystem and human health (Pham *et al*., 2013; Tran *et al*., 2014). Increased use and misuse of chemical pesticides in agriculture are becoming a serious issue in Vietnam. Hence, it has been paid serious attention by all related stakeholders, including policymakers, management agencies, scientists, traders, agriculture producers as well as consumers (Phung *et al*., 2012; Pham *et al*., 2012; Pham *et al*., 2013). The experts have been divided the use of pesticides into three stages. The first stage is a period when pesticides are necessary and beneficial for productivity without harming food safety and the environment. The second stage is a period of excessive pesticide usage and the third stage is a period of pesticide usage crisis. Vietnam is currently transitioning from an excessive usage period to a usage crisis period with the current use of pesticides being over 100,000 tons in a year (Nguyen, 2017; Schreinemachers *et al*., 2020). The pesticide use crisis badly damages the environment, the economy, and public health, which are already evidently happening in Vietnam. Therefore, the elimination of toxic pesticides from farming will ensure the quality of agricultural products as well as the health of users. With an effort to minimize the harmful effects of pesticides on the health

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of farmers and consumers the Plant Protection Department (PPD) has initiated many activities to understand the situation and change the habit of using pesticides in agricultural production. However, the agency admitted that they failed to control the compliance of permitted use of pesticides for farming, despite the government's efforts to control the situation; developing and regularly updating regulations on pesticide management; promoting the use of natural farming; awareness-raising programs on safe use of pesticides for farmers (Phung *et al*., 2012); and recently signed a contract with the biggest media company in Vietnam to build "pesticide use information App"[1] the pesticide use in the Vietnamese agricultural sector keeps increasing (Pham *et al*., 2016; Salazar & Rand., 2020).

Nevertheless, not only the overuse of pesticides but also the unsafe use of pesticides by farmers posed potential impacts on the environment and human health, particularly, farmers themselves (Oluromini yi, 2006; Christos & Ilias., 2011; Pham *et al*., 2012; Miah *et al*., 2014). Previous studies from different countries of the developing world identified various reasons for the unsafe use of pesticides in agriculture. Limited access to the application information, ignoring the risks, unclear safety instructions, and too general directives from related departments; poor knowledge on pesticides; and lacking of a strong legal framework for legal pesticide trade and safe use of pesticides are among the popular reasons (Miah *et al*., 2014; Pham *et al*., 2016; Schreinemachers *et al*., 2020; Abdollahzadeh & Sharifzadeh., 2021). However, many developing countries have not been successful in reducing pesticide use in agriculture, largely because they have limited state capacities and capabilities for developing and enforcing adequate policies on restricting pesticide distribution and use, as well as an inadequate understanding of farming practices related to pesticide use (Pham *et al*., 2016).

Safety knowledge and behaviours in pesticide use are considered as the most important determinants of the adverse health effects of rural people. In addition, the risk of pesticide exposure is strongly associated with farmers' behaviours when they work with pesticides (Sharifzadeh *et al*., 2018). Recent studies in Vietnam indicated that agricultural production is still heavily relying on pesticides and the situation of overuse and unsafe use of pesticides is popular, particularly in mechanical and modern technical rice farming systems (Nguyen, 2017; Salazar & Rand, 2020). However, there is limited information on farmers' perception and behaviours towards safety pesticide use and its determinants, particularly in the central region of the country.

[1]https://play.google.com/store/apps/details?id=eha.sv.ecofarm

This central region of Vietnam is characterised by a small-scale and fragmental farming systems. Rice is the main crop and it is among the top crops using pesticides (Salazar & Rand., 2020). In order to reduce pesticide risks to human health and to save the rural environment, it is important to apprehend farmers' knowledge, perception, and practices of pesticide safety regulations and personal protective equipment (Sharifzadeh *et al*., 2018; Abdollahzadeh & Sharifzadeh., 2021). Previous studies in Iran (Sharifzadeh *et al*., 2018), in India (Sam *et al*., 2008), in South Africa (Naidoo *et al*., 2010) revealed that farmers are highly aware of safety regulations and the necessity to follow them, though many of them do not practice completely or simply ignore. Usually, this happens due to the lack of financial standard, high cost of compliance with the measures, inappropriate design of protective equipment, etc. (Morad *et al*., 2014; Damalas & Abdollahzadeh., 2016; Sharifzadeh *et al*., 2018; Abdollahzadeh & Sharifzadeh., 2021). These studies also indicated that the levels of awareness and practice of safety measures are mostly contextual (vary among regions and communities). It is thus necessary to explore the levels of knowledge of safe pesticide use and practice and factors that hinder them from practicing safety measures at a specific location. Researchers have conducted numerous studies regarding pesticide use in Vietnam. However, they focused mainly on technical issues like types of pesticides, active ingredients, levels of application, management of pesticide, trades, cost-effectiveness of pesticide application, effective pesticides for particular crops or choices of pesticides, etc. So far, there is hardly any study related to farmers' knowledge and behaviours regarding safety pesticide use in Vietnam. That might be the reason for lacking regulations and specific guidelines for different users, particularly for the farmers (Pham *et al*., 2012). Therefore, this study tries to understand the current knowledge and practice of rice farmers on pesticide safety measures (PSMs) and to explore the related barriers.

2 Materials and methods

2.1 Description of the study area

This study was conducted in the central region of Vietnam, where four communes in Quang Tri and Thua Thien Hue provinces were selected for conducting the survey (Fig. 1). The area is bounded with 4 districts namely Quang Dien, Phong Dien, Hai Lang, and Trieu Phong, which are mostly rice-growing areas. The main characteristics of agriculture in the study areas were small scale and fragmented plots, where the average farm size is less than 0.50 hectare per household. The average rice productivity of each district ranges from 51 thousand tons to 62 thousand tons for 2

crops per year (GSO, 2019). The total population of the two provinces was around 1.915.400 of which almost 65 % are relying on agriculture for their livelihoods. The total rice-growing area of the two provinces was about 105.3 thousand hectares and the poverty rate was about 4.67 % in Thua Thien Hue and 6.51 % in Quang Tri (GSO, 2019).

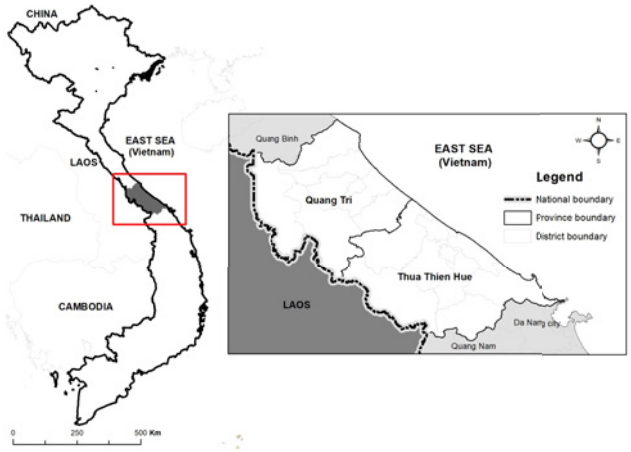

Fig. 1: *Study area in central Vietnam.*

2.2 *Sample selection and data collection*

Data were collected through three different methods: (i) field observation, (ii) group discussion, and (iii) household interviews during the period from April 2020 until May 2021. Two field observations were organized, once during December – January and the other was during May – June. These periods are considered as the pick time of applying herbicides and pesticides for rice crops in the central region of Vietnam. Field observations focused on how the farmers are practising safety measures during agro-chemical operations. Group discussion was organised during the off-season, when majority of the farmers have more free time. Interviews of key informants (leaders of commune and agricultural cooperatives) emphasized the safety measures and indicators for measuring farmers' perceptions and levels of awareness besides the role of related departments in managing pesticide use. The sample size of 323 households for interviewing the questionnaire was derived from a total of 5205 rice farmers following the Slovin model (Formula 1) with the error value e = 0.055. They were randomly selected and the interview sessions were arranged with the head of households or household representatives, who are often responsible for applying pesticides for rice. The questionnaire includes questions about farm household characteristics, the status of pesticide used in rice farming, and farmers' knowledge and practices of pesticide safety measures.

$$n = N/\left(1 + Ne^2\right) \quad (1)$$

Where n indicates the sample size, N is the total population (rice farmers in the communes) and e is the margin of error.

2.3 *Measurements and data analysis*

This study adopted the research framework employed by Sharifzadeh *et al.* (2018). It measures farmers' behaviour using a scale with a set of 39 indicators belonging to 4 components (Table 4, Table 5). They include (i) use of personal protective equipment-PPE (9 indicators), (ii) Avoidance of health risks (12 indicators), (iii) hygiene practice after pesticide use (6 indicators), and (iv) appropriate practice of pesticide use (12 indicators). This framework suits well the 'four-rights' regulation issued by the Vietnamese plant protection department (PPD) to advise farmers regarding pesticide safety use. The four-rights regulation includes "right pesticide", "right time", "right volume/concentration" and "right method". However, the regulation does not have any specific guidance for farmers. This study thus adapted almost every indicator in the study of Sharifzadeh *et al.* (2018), which were developed, and combined from previous research from many Asian and African countries (Qasemi & Karami, 2009; Phung *et al.*, 2013; Damalas & Abdollahzadeh, 2016) and adjusted to be suitable for the conditions of rice farming in Vietnam. Several indicators were found irrelevant to the rice production context of Vietnam such as wearing respirators or coveralls. These indicators were thus replaced by other indicators that are suitable to the rice production system of Vietnam, such as "buying pesticides at the right place (registered shop)", which is in the pesticide management regulation of Vietnam (Article 76, Dec.No21/2015/BNNPTNN). In addition, all the indicators were justified in a way that could be easily understood and get the right answer from farmers and are specific enough to make the research results more practical. So, they are expected to be severed as guidelines for pesticide users in general and rice producers in particular.

Rice farmers were asked to score their knowledge and awareness (perception) regarding the importance of all 39 PSM indicators with the range from 1 - 5, where 1 indicates not important at all and 5 indicates very important. For practising, farmers were asked to score all 39 indicators with the value from 1 - 5, where 1 indicates never practised and 5 indicates always practice whenever use pesticides. The following formula (2) was then used to calculate the farmer's safety level (FSL) of pesticide use based on the practice score of each farmer, which is called the safety behaviour score (PSB). The FSL value ranges between 0 and 1. It can

be understood that the closer of FSL value to "1", the better the safety performance of the rice farmer is (Damalas & Abdollahzadeh, 2016; Sharifzadeh *et al*., 2018).

$$\text{Safety level (FSL)} = (PSB_i - PSB_{min})/(PSB_{max} - PSB_{min}) \quad (2)$$

Where PSB_i = safety behaviour score for the i^{th} farmers; PSB_{min} = the minimum score for safety behaviour in the sample; and PSB_{max} = the maximum score for safety behaviour in the sample.

Damalas & Abdollahzadeh (2016) and Sharifzadeh *et al*. (2018) divided the FSL into five levels of 0.20 points each (totalling 1), following the five-point scale model of Ko (2005) as follows: safe behaviour (excellent): 0.81 – 1.00; potentially safe behaviour (good): 0.61 – 0.80; intermediate behaviour (medium): 0.41 – 0.60; potentially unsafe behaviour (poor): 0.21 – 0.40; unsafe behaviour (bad): 0.00 – 0.20. With a set of 39 indicators under four-rights components of safety regulation measured by the Likert scale from 1 - 5, the regression model is the best to analyse factors influencing farmers' behaviour (Damalas & Abdollahzadeh, 2016; Sharifzadeh *et al*., 2018).

2.4 Statistical analysis

Data analysis and reliability testing were performed using the statistical package SPSS version 22. Summary statistics and frequency distributions were used to describe and interpret data. The final data analysis was conducted using descriptive (mean) and inferential (correlation) statistics. Multiple linear regression analysis was used to examine determining factors influencing farmers' safety behaviour during pesticide handling. The level of significance was a priori set to be < 0.05.

3 Results

The descriptive findings obtained from the survey on the selected characteristics (household information, age, farming experience, education, household agriculture labour force, and household economic status) are presented in Table 1. The mean age of the household heads was 54.39 years with about more than 12 years of farming experience. The average family size is 3.49, among them about 2.06 is at the labour age. Almost 80 % of household heads are in the category of secondary education, where the mean average education is quite high (8.07). On average, each household has 3.53 sources of income with an estimated annual income of 131.48 million Vietnam Dong (5,717 USD) per household. The ratio between poor and near-poor among surveyed households was 20.43 %. Rice is a dominant crop in the study area. Though, the average area under rice farming is only 0.28 ha, indicating the existence of small-scale and fragmented farming.

Farmers used different types of agrochemicals for rice cultivation, which includes herbicides, insecticides, fungicides, plant growth stimulants (PGS), and rodenticides (Table 2). On average, farmers apply agrochemicals about 11.38 sprays per year for two rice crops with a total cost of about 2.70 million VND/ ha/ year (117.39 USD/ ha/ year). The respondents indicated that the application of sprays is increasing, particularly for controlling insects, mice, and snails due to the change in climatic conditions.

However, only half of the respondents (51.2 %) perceived that using pesticides is very harmful and about 11 % perceived it as harmful. Besides this, the rest are inconsiderate of the harmfulness of the agrochemical use (Table 3). Not any poisoned cases due to handling pesticides have been reported by the respondents but about 13.6 % of them have experienced health risks related to pesticide use. More than 54 % of farmers have already received training related to safe use of pesticides from the Department of Plant Protection (DPP) and pesticide suppliers. Unfortunately, only 19.2 % of farmers had periodical health check-ups.

The results of descriptive statistics of farmers' perception regarding the degree of importance of PSMs and levels of practising together with the Wilcoxon test comparisons of each measure are shown in Table 4 and in Supplement 1. The overall mean scores of both levels of knowledge, awareness, and degree of practising PSMs by the rice farmers are considerably high (exceeding 3 of the scale 1 to 5). However, there are significant differences between the level of awareness of the importance of PSMs and the degree of practising ($p < 0.000$), which indicates that the rice farmers are highly aware of the importance and the necessity of PSMs but don't fully practice.

Among the four categories, the use of PPE receives the lowest mean score and has a great difference between levels of awareness and practice of PSMs (3.71 and 2.75, respectively). The average mean score of the total 39 measures remains almost above 3. However, 9 out of 39 PSMs have mean scores of less than 3, and 6 of them are under the category of use of PPE.

The majority of rice farmers in the study area are aware of the importance of avoidance of health risk when using pesticides and practice most of these measures. However, many farmers (71.8 %) still don't care and don't recognise the risk of mixing pesticides in the open air and thus practising wherever comfortable. The category of hygiene practices after using pesticides received the highest mean score among the 4 categories with 4.38 and 4.37 for perception and

Table 1: *Major demographic and socio-economic characteristics of the respondents.*

Demographic / Socio-economic characters	*Unit*	*Mean*	*Std.*
Age of household head	Years	54.39	6.98
Farming experience of household head	Years	12.13	11.40
Highest grade of education of household head	0-12	8.07	1.75
Primary school (under 5 years)	%	10.00	
Secondary school (6 - 9 years)	%	79.26	
High school (> =10 years)	%	10.74	
Family size	Person	3.49	1.59
Household agricultural labour force	Person	2.06	0.67
Area under rice farming	ha	0.28	0.13
Household average income per year	Million	131.48 (VND) (5,717 USD)	82.52
Number of income sources	#	3.53	0.81
Household economic classification (poor and near poor household)	%	20.43	

Table 2: *Pesticide use in rice cultivation in the study area.*

Agrochemicals	*Number of sprays per year / 2 crops*	*Pesticide costs per ha of rice per year*	
		million VND	*USD*
Herbicides	2.81 ± 1.21	0.50 ± 0.27	21.74 ± 11.74
Insecticides	3.23 ± 1.53	0.83 ± 0.36	36.09 ± 15.65
Fungicides	2.17 ± 0.76	0.37 ± 0.18	16.09 ± 7.83
PGS	1.92 ± 0.76	0.47 ± 0.16	20.43 ± 6.96
Rodenticides	4.08 ± 1.59	0.65 ± 0.32	28.26 ± 13.91
Total	11.38 ± 4.24	2.70± 1.17	117.39 ± 50.87

Table 3: *Farmers' perception of pesticide risks and health-related issues (N=323).*

Variables	*Percentage*
Harmfulness of pesticides	
Very harmful	50.8
Harmful	12.1
Not very harmful/ slightly harmful	20.4
Not harmful	14.9
Don't know	1.9
Number of cases poisoned by pesticides	0.0
Health risks related to pesticides use	13.6
Periodical health check-ups	19.2
Farmers receiving trainings related to safety pesticide use	54.2

practices, respectively. The category of the appropriate use of pesticides also had a relatively high mean score (above 4). However, the measures of following toxicity signs on the pesticide containers and do not mix different types of pesticides had very low mean scores (2.89 and 2.71, respectively). The result indicated that mixing different types of pesticides is a popular strategy in the study area. A group of farmers from Quang Phu agricultural cooperative revealed that mixing many types of pesticides saves spraying time and the crops are protected from various risks caused by pests and diseases.

The results obtained through analysing farmer's safety levels showed that, there are variations among the four categories and the majority of farmers are at an intermediate safe or potentially safe level (Table 5). A very high percentage of farmers are under the potentially unsafe (26.3 %) or unsafe (12.5 %) level due to the inappropriate or inadequate usage of PPE when working with pesticides. Overall, a very low percentage (5 %) of rice farmers are under a safe or potentially safe (11.2 %) level. Importantly, more than one-third (34.4 %) of farmers are potentially unsafe and 18.1 % of farmers are under unsafe level.

Results of regression analysis on identifying factors influencing the level of adopting safety measures for pesticide use by the farmers in Thua Thien Hue province are presented in Table 6. $R^2 = 0.615$ indicates that 61.5 % of the variance in

Table 4: *Farmers' perception of importance and practising safety regulations.*

Safety measures	*Importance*	*Practice*	*Z score*	*P value*
Use of personal protective equipment	3.71 (0.66)	2.75 (0.52)	-15.41	0.000
Avoidance of health risk	4.19 (0.41)	4.30 (0.30)	-4.23	0.000
Hygiene practices after pesticide use	4.38 (0.44)	4.37 (0.28)	-0.807	0.245
Appropriate use of pesticides	4.19 (0.33)	4.23 (0.37)	-1.82	0.069
Total	4.09 (0.40)	3.89 (0.22)	-9.49	0.000

Note: Mean on a scale from 1 = never to 5 = almost always.

Table 5: *Pesticide safety level (%) of rice farmers in the study area.*

Safety measures	*Safe*	*Potentially safe*	*Intermediate safe*	*Potentially unsafe*	*Unsafe*
Use of personal protective equipment	20.0	22.5	18.7	26.3	12.5
Avoidance of health risks	9.4	24.3	38.8	18.7	5.6
Hygiene practices after using pesticides	10.6	28.8	51.8	5.7	3.1
Appropriate use of pesticides	25.0	35.0	27.5	8.1	4.4
Total	5.0	11.2	31.3	34.4	18.1

the dependent variable was explained by the variance in the ten independent variables. The multicollinearity among independent variables was checked with VIF < 1.4 and the tolerance level > 0.7 for all predictors indicating no correlation among independent variables. Farmers' perception on health risks of using pesticides showed a strong influencing factor with $\beta = 0.124$, t = 6.625, and $p < 0.001$; followed by farmer receiving related training on PSMs ($\beta = 0.102$, t = 5.812, and $p < 0.001$); and then the factor of farmers' trust on extension workers ($\beta = 0.097$, t = 4.806, and $p < 0.001$). Education level, knowledge about risks of using pesticides, frequent contact with extension workers, and receiving related training positively influence farmers' practising of PSMs. An increase in these elements will lead to an increased level of practising PSMs of rice farmers. Meanwhile, a number of income sources and perceived barriers to the practice of PSMs

Table 6: *Factors affecting the practice of pesticide safety measures by the farmers.*

	Mean score of practicing pesticide safety measures / Dependent variable			
Factor / Independent variables	*Co-ef. (β)*	*SD*	*t. value*	*Sig.*
Age of household head (years)	-0.002	0.001	-1.437	0.152
Household economic classification (0 = poor)	0.035	0.019	3.048	0.003
Education (years)	0.035	0.005	7.105	0.000
Years of farming (years)	-0.002	0.001	-1.513	0.131
Number of income sources	-0.043	0.010	-4.245	0.000
Area under rice farming (ha)	0.135	0.064	2.110	0.036
Frequent contact with extension workers/ plant protection staff (0 = no contact)	0.097	0.020	4.806	0.000
Perceived barriers to practice PSMs (0 = no barrier)	-0.038	0.016	-2.288	0.023
Received related training (0 = no training)	0.102	0.017	5.812	0.000
Constant	3.357	0.086	38.916	0.000
R^2	0.615			0.00
Adjusted R2	0.602			

negatively and significantly influence farmers' practising of PSMs. As farmers have more diverse income sources or they perceive more barriers to practising PSMs they practice less. The poor households practice PMSs less than the non-poor.

4 Discussion

This study explores the levels of perception and practices of PSMs and factors affecting levels of practices PSMs of rice farmers in the central region of Vietnam. It was shown that over 62 % of rice farmers are aware that pesticides are harmful or very harmful but they still rely on pesticides to maintain their production by controlling pests and diseases. Farmers in Hai Vinh commune expressed that *"we know the harmfulness of pesticides but without pesticides, we could not assure the crop yield or no harvest"*. According to the farmers, both the amount (number of sprays/application per rice crop) of pesticides and the types of pesticide use events are increasing over time, due to the increase of pests and diseases with the impact of climate change and due to the availability and cheap price of pesticides. This finding was consistent with many previous studies of Phung *et al*. (2012); Pham *et al*. (2012); Sattler *et al*. (2018) in different parts of the country.

The findings of this research also showed that there remains a significant difference between the perception of the importance of PSMs and the actual practices of PSMs of rice farmers in the central region of Vietnam. It indicates that awareness, knowledge alone are not sufficient to assure farmers' actions to use PSMs. This finding is consistent with the result observed from previous studies of Mohanty *et al*. (2013); Mustapha *et al*. (2017), which also support the communication theory that awareness and knowledge are preconditions but not sufficient for changing behaviour (Antonelli, 2000; Kai & Haines, 2008). According to this theory, almost all communication programs in Vietnam including the safety use of pesticides have been designed to improve knowledge and awareness instead of behaviour change (Phung *et al*., 2012). It is also confirmed that, from knowledge, awareness to changes in behaviour and actions is still a long way that normally has numerous challenges that need to be addressed (Tamara *et al*., 2018). One of the challenges is to practice PSMs by the rice farmers in the study area through getting the related training (Sattler *et al*., 2018). Those who have received trainings related to pesticide use safety significantly had a higher level of practising PSMs than those who have not received any related training. However, the results also showed that not all the farmers who received training are fully practising PSMs because of a lack in information and guidelines. A farmer in Quang Phu said that *"...most of the training organised by the pesticide enterprises in collaboration with extension workers to introduce new type of pesticides. Therefore, the information relates to the effectiveness of new products dominate the training content and very limited information are given regarding safety for the users"*. A representative farmer of Quang Tho cooperative in Quang Dien district also expressed that *"There haven't been any communication programs on safe use of pesticides provided by extension workers or plant protection staff for our community. Only proactive farmers who have a chance to communicate or contact with extension workers or staff of the plant protection department can gain more information on this issue... most farmers here haven't seen such a list of PSMs in this questionnaire. Hence, there should be trainings with a demonstration of detailed guidelines for us"*.This statement explains the significance of farmers' frequent contact with extension workers. Those who do not often contact extension workers haven't fully practised recommended PSMs compared to those who do.

Most rice farmers rely on their previous experience for practising PSMs (Phung *et al*., 2012). Importantly, due to the lack of detailed information and guidelines, farmers rely on their experience, where a high score of practising does not mean safety indicators of rice farmers. For example, instead of using a face shield, farmers use the normal (cotton) face masks, which they use mainly to cover their noses because of the smell from pesticides. The rest parts of their face and body are exposed and they do not care much because they do not feel hurt when working with pesticides. On the other hand, some farmers in Quang Tho commune are using disposable raincoats instead of wearing a protective hat and goggles. This kind of raincoat gets broken easily due to the movement while spraying and carrying the pesticide containers so that it cannot protect farmers as effectively as recommended safety equipment. Therefore, it is not practical to consider the above indicator index alone to assess farmers' safety levels. It needs to combine with other tools such as observation and in-depth interviews. Other challenges include the effectiveness of PSMs measures, particularly the inconvenience of wearing PPE while working with pesticides. These were perceived by the farmers as certain barriers to practice PSMs. Nonetheless, the results revealed from the study also explained the influence of household economic classification on the level of practising safety measures. Since poor households may not afford to invest more in production and safety equipment. This finding is in line with the results from the study by Sharifzadeh *et al*. (2019) that Iranian rice farmers use PSMs made by themselves because of the cost and inconvenience of standard

PPE. Hence, it is suggested to design comfortable and cheap PPE for farmers.

Field survey revealed that farmers who perceive health risks related to pesticides are highly aware of the hazardous effects of pesticides, particularly unknown trademarks and complete dependence on pesticides. Hence, one of the major suggestions of this research is to improve the extension program through the dissemination of updated and detailed information about the hazardous effects of pesticides and correct uses of PSMs with proper demonstration (Bondori *et al*., 2018; Sharifzadeh *et al*., 2018). The farmers also recommended environmentally friendly production systems such as natural farming, IPM, organic farming based on collective actions. They said that *"with collective actions, community gains common understanding, consensus and will gradually reduce the dependency on pesticides. Without collectivism it will not work, like now, most of us don't want to use pesticides but the rest of farmers do. So, we have to follow them otherwise all pests, insects will come to our fields. Related departments should communicate with all farmers to let them understand that paying for higher yield or higher rice productivity by our health is too challenging and too costly…"*. Application of pesticides in rice fields collectively via the management of agricultural cooperatives by hiring a few farmers to spray or using a pesticide-spraying drone for the whole community could be a potential solution (Phung. *et al*., 2012; Pham *et al*., 2013). Such a cooperative system not only saves pesticides and time but also improves the effectiveness of pesticides and protects farmers from pesticide hazards (Mogili & Deepak, 2018).

With highest β value at $P < 0.001$, perceiving health risk in relation to pesticide use is considered as the most important factor influencing farmers' safety level. The regression analysis also indicated that the farmers who perceive challenges to practice PSMs are reluctant to practice safety measures. Improved extension programs may help in changing the farmers' perception to practice PSMs effectively. This opinion is consistent with Sharifzadeh *et al*. (2018); Abdollahzadeh & Sharifzadeh (2021), who suggested that when the farmer fully recognizes the necessity of practising PSMs, they don't consider any difficulties as a barrier to practice. The study also found that the diversity of household income sources negatively influenced the household practice of PSMs ($P < 0.001$), indicating that the more diversified the income sources, the lower is the level of practising PSMs. This can be explained that the households with diverse income sources have less time and attention to take care of their rice fields compared to others. Thi & Thuc, (2017); Ho & Ha., 2017; Nguyen. *et al*., 2019) has reported that many households are trying to diversify their income sources by engaging in off-farm or non-farm activities, which is becoming a trend not only in the study area but also in many parts of the country. Therefore, it is necessary to consider these issues during formulating improved extension and communication programs as well as related trainings.

5 Conclusions and recommendations

This study firstly targeted to explore the farmer's safety level of using pesticide in the rice field, which is considered as the major crop of agricultural production in Vietnam. The results showed that rice farmers are still at a risk of their health due to the unsafe use of pesticides. They are aware of PSMs but do not practice these guidelines completely mainly because of the general lack of understanding of correct practices (dependent on experience), unavailability of PSMs facilities, and poor financial resources. Reluctant to wearing PPE is also the key problem causing potential health hazard to the farmers. The farmers sometimes prefer to apply very large quantities of pesticides or to mix different pesticides in order to save time. The overall findings of the study suggest that the importance of identifying alternatives to hazardous agrochemicals is needed in Vietnam. The farmer should adopt natural farming and collective activism of pest management strategies, which will encourage them to apply a minimum quantity of pesticides and ease their reliance on pesticide use systems. The development of effective and low-cost bio-pesticides could be an alternative to the farmer to protect their health and the environment. Besides, when suggesting a specific pesticide to the farmer the concerned authority should provide information on possible consequences on health and the environment. The farmers must be pragmatic about the countervailing risks associated with significant reduction or elimination of the pesticides from their production systems. However, using the current index alone could not reflect the safety measures. It needs a combination of in-depth investigation as well as observation with proper government policy. Related departments and decision-makers should take the findings of this research into account for the sustainability of the agriculture sector in Vietnam.

Supplement

The supplement related to this article is available online on the same landing page at: https://doi.org/10.17170/kobra-202203085852 .

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Conflict of interest

The authors declare that they have no conflict of interest.

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