Research article

Risk Assessment of Pesticide Use in Chinese kale Cultivation of GAP and Conventional Practice by EIQ in North-East Thailand

JARUPONG PRASOPSUK
Office of Agricultural Research and Development Region 3, Ministry of Agricultural and Cooperatives, Khon Kaen, Thailand

ARUNEE PROMKHAMBUT*
Faculty of Agriculture,Khon Kaen University, Khon Kaen, Thailand

SUWIT LAOHASIRIWONG
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

CHULEEMAS BOONTHAI IWAI*
Faculty of Agriculture,Khon Kaen University, Khon Kaen, Thailand
Email: chuleemas1@gmail.com

Received 10 September 2019 Accepted 21 July 2020 (*Corresponding Author)

Abstract This study reports the pesticide application and environmental impact in Chinese kale cultivation under Good Agricultural Practice (GAP) and conventional practice in North-East, Thailand. The Environmental Impact Quotient (EIQ) model was applied in this study. The data were collected by using semi-structured interviews and observation. GAP farmers (farmers in GAP's system) and conventional cultivation farmers (non-GAP farmers) were purposive selected, 10 per each group with a total of 20 farmers. Data from farmer interviews on pesticides application, type of substances, application rates, frequency, and plot size were used in the EIQ Field Use equation to assess environmental risks between the two practices. The criteria are EIQ Field Use; <25 = very low risk <50 = low risk 50-99 = moderate risk 100-199 = high risk and> 200 = very high risk. The results showed that 15 active ingredients in pesticide were found in GAP farms and 19 active ingredients in pesticide use were found in non-GAP farms. The GAP Chinese kale has a lower level of impact on environmental risks than the conventional one (Average EIQ Field Use: GAP = 87.4, non-GAP = 136.87). This data indicates that the GAP system could reduce the risk of pesticides in the environment of commercial vegetable-growing village.

Keywords environmental impact quotient, pesticide risk, good agricultural practice

INTRODUCTION

The increasing rate of pesticides application poses enormous challenges to manage the associated risks to people and ecosystems (Schreinemachers et al., 2017; Harnpicharnchai et al., 2013). In conventional agricultural practice, the application of pesticides is a common practice among vegetable grower due to the prevalent pest and disease problems. Pesticides are products that improved agricultural productivity, although their inherent toxicity and misuse have led to various adverse effects on important ecosystems and human health (Páez et al., 2013). Although nowadays consumers are increasingly concerned about food safety and looking for safer food (Schreinemachers et al., 2012). To reduce potential food hazards and increase the good image of Thai horticultural products abroad, the Thai government introduced public standards of Good Agricultural Practice (GAP). This has been shown that the application of pesticides in a GAP system is a production strategy that ensures sustainability and competitiveness. An environmentfriendly agricultural production and a contribution to the health of workers, consumers and other stakeholders in the food chain, facilitate trade and international opportunities (Páez et al., 2013).

The long-term strategies to manage risks in the GAP system, farmers can pesticide to control weeds, pests, and diseases following the principles of Integrated Pest Management (IPM) because Good Agricultural Practice will be decided on interventions following consideration of all possible methods and their short and long-term effects on-farm productivity and environmental implications in order to minimize the use of agrochemicals, in particular, promote IPM (FAO, 2004). However, some growers and pest management practitioners did take into account the effect of the pesticides on the applicator or beneficial natural enemies such as predatory mites when making pesticide recommendations, but no formal method was available to assist them in making environmentally based pesticide choices. Because there is no easy method to assess pesticide impacts, each individual had to rely primarily on their own judgment to make these decisions (Kovach et al.1992).

The Environmental Impact Quotient (EIQ) is a formula created to provide growers with data regarding the environmental and health impacts of their pesticide options, so they can make better informed decisions regarding their pesticide selection. (Cornell University, 2018) The formula helps to calculate the environmental impact of most common fruit and vegetable pesticides (insecticides, acaricides, fungicides and herbicides) used in commercial agriculture. The values obtained from these calculations can be used to compare different pesticides and pest management programs to ultimately determine which program or pesticide is likely to have the lower environmental impact. The method addresses a majority of the environmental concerns that are encountered in agricultural systems including farm worker, consumer, wildlife, health and safety (Kovach et al., 1992). Since 2000, the EIQ has been used in several IPM projects in Asia for different purposes ranging from impact assessment to pesticide selection (FAO, 2008).

Chinese kale is one of the main vegetable growing in Khon Kaen province in North-East, Thailand and is one of the major vegetable consumed in the region (National Bureau of Agricultural Commodity and Food Standards, 2016). The vegetable is also susceptible to a substantial number of arthropod pests and plant diseases, which farmers need a lot of pesticides to prevent crop damage. For the commercial vegetable village in this study area, GAP farmers have used pesticides less than non-GAP farmers because they were supported to pesticides used in accordance with IPM. However, there are no indicators that GAP can reduce the risk of pesticides used. Therefore, the EIQ impact assessment will show the risk levels of both Chinese kale cultivation (GAP and non-GAP). This will be answered that whether GAP compliance can reduce the risk of pesticides on environmental and health impacts or not. Moreover, it is expected that the results of the study can also be used to help governmental agencies to implement better GAP programs in this region.

OBJECTIVE

To assess pesticide risk and environmental impact in Chinese kale cultivation among GAP and conventional practices.

METHODOLOGY

Data Collection

The commercial vegetable growing village in Muang District, Khon Kaen Province, Thailand was purposively selected as a study site in this research. This village is a large vegetable production in the area which farmers continue to grow vegetables for more than 30 years as it is the main source of their incomes. At the same time, this village is one of the pilot GAP vegetable production areas by the government. Since it is a voluntary scheme, there are both GAP farmers and non-GAP farmers in the village. In this study, Chinese kale plots were purposively collected from 10 GAP and 10 non-GAP plots, as their farms scattered across the village. Pesticide application data were collected by using a semi-structure interview and making observations, during January to October 2018. Data of pesticide compound, common name, active ingredient, % active ingredient, rate of application, frequency of application and plot size were collected from sample plots.

Risk Assessment of Pesticide used by EIQ

The EIQ value for a particular active ingredient is calculated according to a formula that includes parameters of toxicity (dermal, chronic, bird, bee, fish, and beneficial arthropod), soil half-life, systemicity, leaching potential, and plant surface half-life are considered. The formula for determining the EIQ value of individual pesticides is listed below and is the average of the farm worker, consumer, and ecological components. The EIQ Equation as in Eq.(1) (Kovach et al., 1992).

$$EIQ=\{C[(DT*5)+(DT*P)]+[(C*((S+P)/2)*SY)+(L)]+[(F*R)+(D*((S+P)/2)*3)+(Z*P*3)+(B*P*5)]\}/3 \quad (1)$$

Where DT = dermal toxicity, C = chronic toxicity, SY = systemicity, F = fish toxicity, L = leaching potential, R = surface loss potential, D = bird toxicity, S = soil half-life, Z = bee toxicity, B = beneficial arthropod toxicity, P = plant surface half-life.

Field Use EIQ is calculated by multiplying the table EIQ value for a specific chemical by the percentage of active ingredient in the formulation and its dosage rate per hectare, as in Eq. (2)

$$\text{Field Use EIQ} = \text{EIQ value} \times \% \text{ active ingredient} \times \text{Dosage rate} \quad (2)$$

The risk level according to the EIQ Field Use Rating Levels; when EIQ Field Use less than 25 = very low risk, less than 50 = low risk, 50-99 = moderate risk, 100-199 = high risk, over than 200 = very high risk (Cornell University, 2018).

RESULTS AND DISCUSSION

Pesticide Applied in Chinese Kale Cultivation

In each crop production, different frequencies of different types of pesticides were found applied in both GAP and non-GAP plots. The insecticides that commonly applied in all production cycle in both plots indicating that insect damage in Chinese kale production in this area was critical and approaches to reduce the infestation of insect must be seriously taken in to account. The types of pesticides applied by farmers (GAP and non-GAP) were not different because most farmers buy pesticides at the agro-chemicals shops in the village. For example, imidacloprid was commonly used for control worms and aphids because this product is inexpensive, and easy to obtain from shops in the village. In the rainy season, during the high pest epidemics, farmers will use pesticides with higher toxicity levels, such as tolfenpyrad, profenofos and cypermethrin. However, considering number of chemicals used, GAP farmers used less than non-GAP farmers (Table 1).

Based on a survey of pest control in the field, GAP farmers tried to use integrated pest management methods, which were bio pesticide such as azadirachtin, *Baciluss thuringiensis*, *Trichoderma harzianum* and *Steinernema sp.* Moreover, they also applied insect net for protection against pests with government support, which non-GAP farmers do not have. This may be the reason of fewer number of pesticides applied by GAP farmers and also indicate the important of intervention form government agencies in terms of production and reducing pesticide application. However, factors affecting farmers' decision to apply pesticides include labor, market motivation, disease and insect outbreaks, and size of vegetable plots.

Risk Assessment of Pesticide Applied in Chinese Kale Cultivation

The EIQ Field Use values were calculated by using data of pesticide applied in farmlands. The results of calculated EIQ Field Use for assessing pesticide risk revealed that EIQ Field Use (n =10) of GAP farmers was in the range of 28-131 and the average EIQ Field Use values is 87.42 (Rating level=moderate risk). Although the EIQ Field Use (n =10) of non-GAP farmers was in the range 30–393 and the average EIQ Field Use values is 136.87 (Rating levl= high risk). This data shown in Table 2.

Table 1 Pesticide application of GAP and non-GAP farmers in Chinese kale plots

Pesticides	Type	%Active ingredient	Application rate per 20 L water		Frequency of application per crop	
			GAP	non-GAP	GAP	non-GAP
abamectin	I	1.8%W/V EC	20-30 ml	20-30 ml	3-6	3-6
acetamiprid	I	20% SP	5 g	5 g	2	2
alachlor	H	48%W/V EC	150 ml	100-175 ml	1	1
carbaryl	I	85%WP	20 g	30 g	1	3
chlorfenapyr	I	10%W/V EC	40 ml	40 ml	1	1
chlorantraniliprole	I	5.17%W/V SC	40 ml	-	2	-
chlorpyrifos+cypermethrin	I	50%+5%W/V EC	-	20 ml	-	6
cypermethrin	I	35%W/V EC	10-20 ml	10-30 ml	1-6	3
diazinon	I	60% W/V EC	-	40 ml	-	1
dichlorvos	I	50%W/V EC	40 ml	10-60 ml	3	2-6
dinotefuran	I	10% WP	-	10-15 g	-	1-4
emamectin benzoate	I	5% WG	-	10 g	-	2
haloxyfop-p- methyl	H	10.8%W/V EC	50 ml	50 ml	1	1
imidacloprid	I	70% WG	5 g	10 g	2	2
indoxacarb	I	15%W/V EC	-	10 ml	-	1
mancozeb	F	85%WP	50 g	40 g	1	6
oxadiazon	H	25%W/V EC	100 ml	100 ml	1	1
profenofos	I	50%W/V EC	20 ml	10 ml	3	4
spinetoram	I	12% W/V SC	15 ml	10 ml	3	4
tolfenpyrad	I	16% EC	20 ml	40 ml	1	1-5

Remark: Collected samples (N=20) from 10 GAP and 10 non- GAP farmers interviews in March to May 2018 of Muang District Khon Kaen Province Thailand. I= Insecticide, H=Herbicide, F= Fungicide, Application rate per 400 m^2 plot size.

Table 2 EIQ Field Use of GAP and non-GAP Chinese kale cultivation

Type of Chinese kale cultivation	EIQ Field Use (Min-Max)	Average EIQ Field Use	S.D.	Risk rating
GAP (N=10)	28-131	87.42	31.38	Moderate risk
non-GAP (N=10)	30-393	136.87	115.76	High risk

Remark: when EIQ Field Use less than 25 = Very low risk, less than 50 = Low risk, 50-99 = Moderate risk, 100-199 = High risk, over than 200 = Very high risk (Cornell University, 2018).

The numbers of GAP and non-GAP Chinese kale farms classified by EIQ Field Use rating are presented in Fig.1. The result of calculated EIQ Field Use risk assessment of pesticide application revealed that in 10 GAP farms there are4 farms with high risk levels (40%), 5 farms with moderate risk levels (50%) and 1 farm with low risk levels (10%). Within the 10 non-GAP farms, there are 3 very high risk levels (30%), 2 farms with high risk levels (20%), 4 farms with moderate risk levels (40%), and 1 farm with low risk levels (10%).

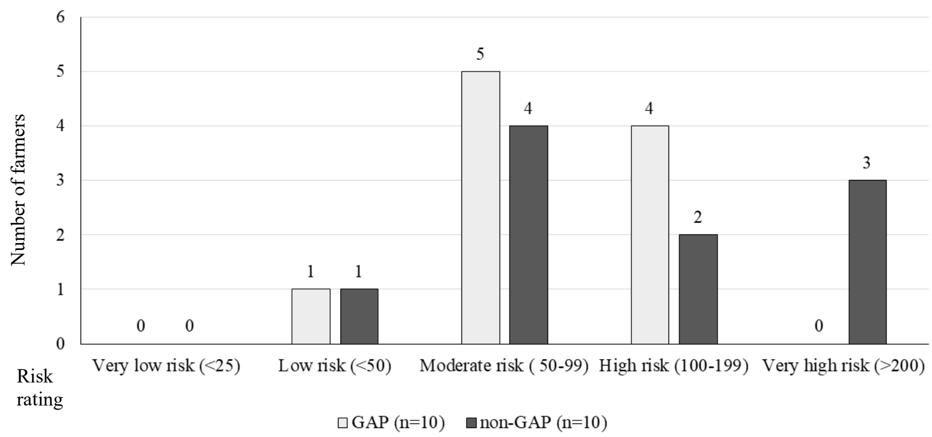

Fig.1 Number of GAP and non-GAP Chinese kale farms classified by EIQ Field Use rating

CONCLUSION

GAP Chinese kale cultivation has a lower level of impact on environmental risks than that of conventional one (Average EIQ Field Use: GAP = 87.4, non-GAP = 136.87). This data indicates that the GAP system could reduce the risk of pesticides application in the environment of commercial vegetable-growing village.

ACKNOWLEDGEMENTS

This study was funded by The Agricultural Research Development Agency (Public Organization) Bangkok, Thailand. The authors would like to thank the Office of Agricultural Research and Development Region 3, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand for participating in this research.

REFERENCES

Cornell University. 2018. A method to measure the environmental impact of pesticides. Environmental Impact Quotient: An Introduction. https://nysipm.cornell.edu/eiq.

FAO. 2004. Good agricultural practices a working concept background paper for the FAO internal workshop on good agricultural practices, FAO Agriculture Department. FAO GAP Working Paper Series 5. Food and Agricultural Organization of the United Nation. Rome, Italy.

FAO. 2008. IPM impact assessment series. Review use of environmental impact quotient in IPM programmed in Asia. Food and Agricultural Organization of the United Nation, Rome, Italy.

Harnpicharnchai, K., Chaiear, N. and Charerntanyarak, L. 2013. Residues of organophosphate pesticides used in vegetable cultivation in ambient air, surface water and soil in Bueng Niam Subdistrict, Khon Kaen, Thailand. Southeast Asian J. Trop. Med. Public Health, 44, 1088-1097.

Kovach, J., Petzoldt, C., Degnil, J. and Tette, J. 1992. A method to measure the environmental impact of pesticides. New York's Food and Life Sciences Bulletin. New York, Cornell University, New York, USA.

National Bureau of Agricultural Commodity and Food Standards. 2016. Food consumption data of Thailand. Bangkok, Thailand.

Paez, M., Sánchez, R. and Castro, R. 2013. Environmental impact quotient (EIQ) as an indicator for the sustainability in tomato crops with traditional and GAP’s systems. Department of Caldas. Colombia. https://www.york.ac.uk/conferences/yorkpesticides2013/pdfs/134.pdf.

Schreinemachers, P., Chen, H., Nguyen, T.T.L., Bontong, B., Bouapao, L., Guatam, S., Le, N. T., Pinn, T., Vilaysone, P. and Srinivasan, R. 2017. Too much to hand? Pesticide dependence of smallholder vegetable farmers in Southeast Asia. Sci. Total Environ., 593-594, 470-477.

Schreinemachers, P., Schad, I., Tipraqsa P., Williams, P. M., Neef, A., Riwthong. S., Sangchan, W. and Groverman, C. 2012. Can public GAP standards reduce agricultural pesticide use? The case of fruit and vegetable farming in northern Thailand. Agric. Hum. Values, 29, 519-529.