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Impact of VietGAP Vegetable Production on the Health of Farmers in Thua Thien Hue Province, Vietnam

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Front cover photo: VietGAP vegetable production in Quang Dien district, Thua Thien Hue province, April 2015 by Tran Huynh Bao Chau

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October, 2015

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IMPACT OF VIETGAP VEGETABLE PRODUCTION ON THE HEALTH OF FARMERS IN THUA THIEN HUE PROVINCE, VIETNAM

Tran Huynh Bao Chau and Le Thi Quynh Anh

EXECUTIVE SUMMARY

This study estimated the impact value of the VietGAP program when applied to vegetable production on the health of farmers in Thua Thien Hue province. By employing the propensity score matching (PSM) method, the results of this study show that the VietGAP program has a significant impact on farmers' health. In particular, the program reduces farmers' health problems due to pesticide exposure by 15.6%–25.5% (depending on the assessment calculation used). Most health problems due to pesticide exposure are moderate in severity and have short-term effects. Conventional farmers experience more health problems with more significant symptoms than VietGAP farmers do. By applying the health cost derived from direct and indirect costs, the health impact value of the VietGAP program is estimated to be VND 521,870 per farmer per year.

Many farmers are aware of the harmful effects of pesticide use; intensive use of pesticides and using inadequate protective equipment increase the health risks faced by farmers. This study provided evidence of the positive impacts of the VietGAP program on the health status of farmers in Thua Thien Hue province. It is therefore hoped that the production, consumption, and management solutions provided by the VietGAP program can encourage farmers to use environment-friendly agricultural practices.

1.0 INTRODUCTION

1.1 Research Background

Exposure to pesticides is an occupational hazard for farmers in developing countries. According to FAO (2010), there is a high incidence of contamination and poisoning in crop farmers due to pesticide use. The severity of each hazard depends on the toxicity of the pesticide, the means of exposure, and the extent of the exposure (Hashmi and Dilshad 2011). Different families of chemicals cause different types of symptoms, and individuals vary in their sensitivity to each level of chemical. In general, short-term exposure to high doses of pesticides can cause skin, eye, nose, and throat irritation; difficulty in breathing; impaired lung function; delayed response to a visual stimulus; headaches; impaired memory; stomach discomfort; fever; muscle weakness; and possible changes in the liver and/or kidneys. Both short- and long-term exposures can potentially affect the nervous system (Hashmi and Dilshad 2011).

Dermal exposure occurs when a farmer does not wash his/her hands after handling pesticides or pesticide containers. Pesticides can also get on the skin when farmers wear pesticide-contaminated clothing and when they apply pesticides during windy weather. Touching treated plants or soil also leads to dermal exposure. Meanwhile, oral exposure usually happens when farmers, after using pesticides, do not wash their hands before eating or smoking; when they store pesticides in drink containers and then reuse the containers for drinking purposes; when pesticides are accidentally applied to food; and when the spray are blown onto the lips or into the mouth during pesticide application. Inhalation exposure can occur when farmers spray pesticides and when they mix powder-form pesticides or other dry pesticide formulations without using proper protective gear. Likewise, using inadequate or poorly fitted respirators increases the possibility of inhalation exposure. The possible adverse effects from inappropriate pesticide use or regular contamination with pesticide residue can result in acute poisoning and chronic health impairment in the form of hepatic dysfunction, nephrotoxic effects, chronic toxicity, carcinogenesis, and oxidative stress (Hashmi and Dilshad 2011). Due to the health risks associated with pesticide use, farmers need to recognize the common signs and symptoms of pesticide poisoning.

From 2007 to 2011, there were about 40,000 cases of food poisoning in Vietnam; 4,800 of which required hospital admission (Health Ministry 2012). An investigation conducted by the Institute of Policy and Strategy for Agriculture and Rural Development proved that of the 1,050 samples of three types of vegetable collected from eight provinces, 51% of the sampled vegetables contained residues of plant protection chemicals and heavy metals. Prolonged exposure to pesticides can adversely affect the health of Vietnam's populace. Accordingly, because farmers deal with pesticides in their work, this negative impact on their health can manifest itself to a disproportionate degree within farming communities.

A survey of farmers in Binh Chanh clarified that the frequency of health symptoms from prolonged exposure to pesticides used in conventional farming is different depending on the levels and doses of pesticides used, differences in the type of chemicals used, and farmer characteristics (Ngan and Thang 2006). Sprayers were particularly associated with eye and skin problems, headaches, and general discomfort. The severity of the hazards increased with the dose of pesticides used when the treatment and control groups were compared.

Unregulated and excessive use of pesticides have compounded the hazards associated with pesticide use (Hashmi and Dilshad 2011), although pesticide risk reduction and risk management play an essential role in agricultural practice (FAO 2010). In developing countries, the low levels of education in the rural areas, limited information on and training in pesticide safety, poor quality of protective equipment, and inadequate precautionary equipment increase the potential for harm (Hurtig et al. 2003; Atreya 2008). Therefore, the government should focus on raising farmers' awareness of the negative health effects of unsafe pesticide use and on promoting the importance of communication and education programs that aim to reduce health risks. In addition, environment-friendly agricultural practices should be introduced and expanded in order to encourage greater public health and food safety.

The production of safe vegetables has been publicly approved via a bias toward environment-friendly agricultural practices. It is then important to minimize the potential hazards of pesticides by lowering farmers' reliance on pesticides, by selecting pesticides with the lowest toxicity-risk to human health and the environment for use in crop production, and by properly using recommended products in accordance with international environment-friendly standards (FAO 2010). In addition, the attitudes of farmers who have been appropriately educated and trained play a crucial role in safe crop production.

There is an increasing focus on the promotion of good agricultural practice (GAP) on farms, in agribusiness, and in the food industry. GAP provides an advanced approach to better production practices, and results in less environmental contamination during production and fewer pesticide residues in agricultural products (FAO 2010). Production under GAP schemes and protocols offer an opportunity for farmers to better select and utilize pesticides within national and international quality standards. With the long-term incentives currently available, applying GAP could create sustainable benefits for farmers.

The Vietnamese government has made every effort to introduce and conduct national policies and regional pilot programs to encourage communities to produce safe vegetables and environment-friendly food. VietGAP (Vietnamese Good Agricultural Practice) is one such program; it aims to create and change producers' and consumers' behaviors (MARD 2008).

Thua Thien Hue province in Central Vietnam operates pilot programs in safe vegetable production. Quang Dien district is known for its vegetable production and for simultaneously running VietGAP production and conventional production of a diverse range of tropical vegetables. Quang Dien district is located on the north of Thua Thien Hue province, around 15 km from Hue city. The VietGAP program has been operating in the district using the organizational framework and with the technical support and initial financial approval of the Department of Science and Technology, the Department of Agriculture and Rural Development, the Agricultural Extension Center, and Hue University of Agriculture and Forestry (Provincial Department of Science and Technology 2011). To date, around 150 farming households at the study site have followed VietGAP production guidelines. The safe production of vegetables using the VietGAP program has been implemented by household participants, agricultural cooperatives, and small business enterprises (Provincial Department of Science and Technology 2011). Favorable climate and land conditions, a resourceful workforce, and the availability of multiple markets have sharpened the scheme's initial advantages.

The regions selected for VietGAP vegetable production need to have the appropriate soil and topography. After analyzing the water supply and soil type in terms of their heavy metal and chemical residues, the project proponents select the household participants. The decision to participate in VietGAP can be associated with individual characteristics such as educational background, personal perceptions and production experience, economic conditions, and the physical features of the land, such as soil type.

The distinguishing features of VietGAP that differentiate it from conventional farming practices include the former's adoption of different production standards and the use of different types of fertilizers and pesticides, which are usually environment-friendly. The production procedure must follow the technical criteria set by VietGAP in terms of input management for seeds, fertilizers and plant protection products, harvest management, and waste management (MARD 2008). The production of certified vegetable crops also requires more labor and is subject to stricter regulation than that of conventional crops. Agricultural cooperatives and local governance play important roles in introducing, assisting, and encouraging farming households to engage in VietGAP standards by helping farmers via the provision of agricultural services and technical consultancy (Provincial Department of Science and Technology 2011).

In spite of the initial challenges with regard to market access, participation in the VietGAP program was approved for the purpose of community health protection. Farmers typically have inadequate information on the health impacts of pesticide use, which may discourage them from converting from conventional production techniques to certified safe production. Therefore, the health risks associated with pesticide use in conventional production need to be clarified via empirical evidence.

Can the VietGAP program improve the health status of local farmers in Thua Thien Hue province? One of the objectives of this study is to examine the causal effect of VietGAP program participation on the health of farmers, thus providing incentives for local communities to work toward safe food production. Once producers understand the value of VietGAP production on their health status, it is expected that environment-friendly practices will be adopted on a larger scale.

By comparing the health status of conventional farmers with that of VietGAP farmers, this study was able to determine the effects of VietGAP participation on farmers' health. Investigating farmers' knowledge, attitudes, and perceptions about pesticide-handling and pesticide safety is essential in addition to providing information regarding the incidence of pesticide-related illness, the severity of acute poisoning symptoms, and the associated cost of illness (Hashmi and Dilshad 2011; FAO 2010). Noticeably, there is a time lag between chemical exposure and its effect on a farmer's health. VietGAP started in 2010; the period of 2010 to the present [June 2015] would already be sufficient to establish a causal connection between pesticide use and farmers' health, because farmers can already feel adverse health impacts within that five-year period. From the broader view of international agriculture trade, pest sensitivity is linked to national levels of income, education, and food safety. By using pesticides to control pests, the risk of toxic residue being left in food increases. Policy reforms have been more focused on food safety (Rola et al. 1998; Dasgupta et al. 2002). Accordingly, the present study is ultimately expected to increase farmers' awareness on the importance of safe vegetable production in terms of health protection.

1.2 Research Objectives

In general, this study aimed to estimate the impact value of the VietGAP program (when applied to vegetable production) on the health of farmers. It also aimed to make farmers become more aware of the importance of safe food production as an aspect of health protection. In order to reach these objectives, the following research questions were asked:

1. Has the VietGAP program improved farmers' health? Is there any statistically significant difference in the causal effect of the VietGAP program on farmers' current health problems due to pesticide exposure? To what extent (if any) has the VietGAP program improved the health status of farmers?
2. What is the economic value of the health status improvement (called the "health impact value") of the VietGAP program?
3. What are the farmers' perceptions of the hazards posed by pesticides? What precautionary behaviors do farmers engage in to protect themselves from the health risks posed by pesticide use?

1.3 Research Scope

This study selected Quang Dien, Huong Tra, and Huong Thuy districts in Thua Thien Hue province as the sampling sites for the farmer survey. These districts have many vegetable production areas that provide most of the demand for vegetables of both rural and urban residents of the province. Given the time constraints, we concentrated on the commonly self-reported health problems resulting from using pesticides via conventional production and via VietGAP production and their corresponding costs. The study excluded extraordinary potential long-term health effects such as genetic disorders and cancers.

2.0 REVIEW OF LITERATURE

Theoretically, adopting GAP provides health benefits as it would change farmers' pesticide use and hygienic practices (Asfaw, Mithöfer, and Waibel 2009). However, although the health risks associated with pesticide use and their costs are now gradually becoming understood, the positive potential offered by the adoption of GAP standards has not yet been realized. This is because only a few studies have provided empirical evidence of the causal effects of GAP participation on farmers' health. It is widely recognized that the initial barriers of labor expense and technical requirements in new advanced production methods still have an impact on the decision to convert from conventional production to certified environment-friendly production (Uematsu and Mishra 2011). However, once farmers learn and understand the health risks posed by using high doses of pesticides and the associated health impact value of this usage, they would become motivated to convert from conventional production to certified safe production.

This study primarily expects to contribute to the existing literature that presents empirical evidence on the health benefits that can be gained from the VietGAP program. Health concerns used to be identified as a motivation for safe vegetable production (Simmons and Scott 2007), and some safe production programs have been implemented in Vietnam. However, some of the information on the estimated causal effects of these programs on the health attributes linked to the economic valuation of health impacts may be misleading. Rola and Pingali (1993) cited the impact of pesticide dosage on productivity in the production function in order to obtain the appropriate spray level of chemicals in crop production. Dung and Dung (1999) considered health impacts by valuing the economic health consequences of pesticide use in the paddy production of farmers in the Mekong Delta; the authors denoted the health factors associated with its use through the health impairment and health cost, given the pesticide dosage used in conventional paddy production. These studies were conducted in the context that farmers mostly implement conventional production, in which farmers personally control the pesticide dosage applied. In other words, most of the recent empirical results measure the health impact value of the standardized production safety programs on farmers.

This study examined the farmers who have adopted the VietGAP program, in which inputs are compulsorily used via standardized schemes. Since farmers need to use pesticides within a specified set of criteria, the health attributes tend to be more evidently perceived from the farmer's viewpoint. The VietGAP program has been implemented in Thua Thien Hue province for nearly five years; thus, it is easier to compare the health attributes of the VietGAP participants with that of the nonparticipants among local farmers. This provides encouraging proof for the sustainability of the program.

In Germany, previous literature has mentioned the impact of applying standards on agricultural output and farm structure (Pufahl and Weiss 2008). In particular, the participants of agri-environment program schemes were found to have been able to increase significantly their cultivation area and reduce their purchase of farm chemicals, which accordingly play a vital role in international agricultural trade negotiations. In Kenya, estimation results show that farmers' participation in Global GAP standards has a positive and significant impact on their health, both in terms of a reduction in pesticide-related acute poisonings and their associated cost of illness (Asfaw, Mithöfer, and Waibel 2009). In Vietnam, there is limited available information that explains the severity, medical costs, number of working days off, and the corresponding cost of health attributes. In estimating the monetary value of the negative impacts of pesticide use on farmers' health, it is necessary to take into account not only the incidence of production-induced health problems, but also their severity, which can be illustrated through the number of working days lost and other associated health costs.

Secondly, this study expects to contribute to the existing literature on the endogeneity treatment of VietGAP participation via the PSM method. The causal effect of certified safe production on household income from economic perspectives has been investigated in other studies using the PSM method (Uematsu and Mishra 2011). However, in the context of Vietnam, there is still limited data and information about the effect of VietGAP participation on farmers' health when treating the endogeneity of farmers' participation in the program.

The decision to participate in VietGAP is one of self-selection; it can be associated with individual characteristics such as age, educational background, cultivation experience, and production features. Accordingly, the self-selection factor in VietGAP participation can contribute to the endogeneity problem in the empirical analysis of the causal effects of the VietGAP program on the health of local farmers. The PSM method aims to balance the sample into comparable treatment groups—those who are participating in the VietGAP program (i.e., participant group) and those who are not (non-participant group or the control group). By using matching techniques, we can measure the outcome change through the average treatment of the treated (ATT) of VietGAP participation on the possibility that farmers would experience health problems due to pesticide use.

3.0 METHODOLOGY

3.1 Survey Design and Data Collection

This study employed secondary and primary data in the analysis. The secondary data consist of the current situation in both conventional vegetable production and safe vegetable production. The data were obtained from provincial documents, annual reports, and project reports. Primary data include a survey of 200 farmers who use VietGAP and conventional vegetable farming methods in Quang Dien, Huong Tra, and Huong Thuy districts in Thua Thien Hue province.

Quang Dien district is known for producing a diverse range of tropical vegetables. The area allotted for vegetable production in the district is 3.880 ha, which accounts for nearly half of its agricultural land. Huong Tra district is the northern gateway to the province, around 17 km from Hue city. The area allotted for vegetable production in Huong Tra is 2.794 ha. Meanwhile, Huong Thuy district is the southern gateway to Thua Thien Hue province, which is around 6 km from Hue city. It has about 1.686 ha of vegetable production area (Figure 1). These districts have significant experiences in vegetable production and in the associated supply chain. Vegetable production has traditionally generated a significant income for local farmers in the districts.



Figure 1. The study sites in Thua Thien Hue province

This study implemented a survey of 77 VietGAP farmers in Quang Dien district and 123 conventional farmers in Quang Dien, Huong Tra, and Huong Thuy districts based on purposive selection. The questionnaire was designed to survey information on individual characteristics, production features, health attributes, and personal perceptions of pesticide hazards and production safety. Note that the health attributes include the incidence and severity of health problems derived from exposure to pesticides. Information on pesticide exposure, perceptions of the toxicity of pesticides, and precautionary attitudes were also investigated.

3.2 Propensity Score Matching Method

3.2.1 Factors associated with the probability of VietGAP program participation

The probit model aims to estimate the likelihood of the association of some individual factors with the probability of VietGAP program participation. The equation of the probability of VietGAP program participation was constructed under the following probit models:

$$Prob(VietGAP = 1) = \Phi(X, \alpha) \quad \text{Equation (1)}$$

where:

<i>VietGAP</i>	=	binary variable equal to 1 when the respondent has participated in the VietGAP program and 0 otherwise;
Φ	=	cumulative distribution function of the standard normal distribution;
<i>X</i>	=	set of individual variables, including gender, age, educational background, income, individual habits, production area, cultivation experience, and annual duration of exposure to pesticides; and
α	=	parameter typically estimated by maximum likelihood.

3.2.2 Causal effect of VietGAP program participation on the appearance of health problems due to pesticide exposure

This study employed the PSM method to estimate the average treatment effect (ATE) of VietGAP program participation on farmers' health problems due to pesticide exposure. The decision to participate in VietGAP is one of self-selection, which is associated with both individual characteristics and production features. In other words, farmers are not randomly assigned to produce vegetables via conventional farming methods or via using the VietGAP procedure. Treated and controls differ with respect to participation status and other characteristics.

The estimation of ATE is ideal when we can simply compare the appearance of health problems due to pesticide exposure when a farmer is using VietGAP products to when s/he is not. In such cases, ATE on the outcome variable can be expressed as

$$ATE = E(Y^1 - Y^0) \quad \text{Equation (2)}$$

where:

Y^1	=	health problems due to pesticide exposure of farmer with VietGAP participation ($P = 1$), and
Y^0	=	health problems due to pesticide exposure of farmer without VietGAP participation ($P = 0$).

However, one practical problem that arises given a cross-sectional data set is that we can observe either Y^1 or Y^0 only, because the assignment is mutually exclusive. Thus, estimating the ATE of being a VietGAP farmer on the appearance of health problems due to pesticide exposure hinges on the estimation of the counterfactual (Wooldridge 2001). It is then necessary to estimate the probability of health problems appearance due to pesticide exposure that a farmer participating in the VietGAP program would have gotten if s/he were not participating in the program, or that of a conventional farmer had s/he been participating in the program.

When the assignment to the treatment group can be fully explained by observable variables, any bias inherent in comparing the outcome variables between the control group (conventional farmers) and the treatment group (VietGAP farmers) can be removed by matching the observations in the two groups based on observable variables. When observations in the VietGAP group can be matched against observations in the non-VietGAP group that share similar characteristics based on observable variables, any difference in the outcome variables that may exist can be assumed to be independent of the treatment status.

Rosenbaum and Rubin (1983) proposed the propensity score, which is a conditional probability of VietGAP participation, as follows:

$$P(X) = \text{Prob}(P = 1 | X). \quad \text{Equation (3)}$$

Matching is a non-experimental method of evaluation that is used to estimate the average effect of the VietGAP program. This method compares the mean of the possibility of health problems due to pesticide exposure in VietGAP farmers with those of matched non-VietGAP farmers; matches are chosen based on the similarity in observed characteristics. In this study, the average treatment effect for the treated (ATT) can be formulated as

$$ATT = E(Y^1 - Y^0 | P = 1) = E(Y^1 | P = 1) - E[Y^0 | P = 1]. \quad \text{Equation (4)}$$

It is important to note two assumptions:

1. **Conditional independence.** This implies that given a set of observable X , potential outcomes are independent of treatment assignment after the balancing test ($Y^1, Y^0 \perp P | X$). This procedure assumes that after conditioning on a set of observable characteristics, outcomes are conditionally mean independent of program participation. Any remaining difference in the outcome variable can be solely attributed to treatment status. Assignment to the treatment can be considered purely random among observations with similar observable characteristics.
2. **The overlap.** If $0 < P(X) < 1$, then the probability of participation ranging from 0 and 1 can be considered as common support.

When these assumptions are satisfied, assignment to treatment is random for observations with the same propensity score. Observations in the control and treatment groups can be matched according to the propensity score. In short, PSM balances the sample into comparable participant (treatment) and non-participant (control) groups; the method uses matching techniques to measure outcome change through ATT. Because it is not feasible to find an exact match for every treated observation, a number of matching procedures have been proposed in the literature, including nearest-neighbor matching, radius matching, kernel matching, and local linear regression matching (Becker and Ichino 2002). It is important to note that PSM does not eliminate the selection bias due to unobservable factors that explain assignment to treatment, but it only reduces it (Becker and Ichino 2002). The significant results of matching methods, if there are any, will provide evidence whether the health status of farmers who participate in VietGAP improved or not.

3.3 Health Impact Value of the VietGAP Program

In this study, health attributes are described through the appearance and severity of health problems due to exposure to pesticides. We have already mentioned the probability of health problems arising from pesticide exposure. The severity of these health problems denotes the economic value of the health impacts through their related medical costs, the number of working days lost, and the corresponding income loss. The economic value of an improvement in farmers' health status owing to the VietGAP program, called the "health impact value," is defined as the difference in the economic value between the health problems suffered by VietGAP farmers and that by conventional farmers.

In order to measure the economic value of the health problems induced by pesticide exposure, we employed the "health cost." The cost of medicine, hospitalization, income lost from working days spent visiting the commune health center, and the travel cost to treat or reduce health problems from pesticide exposure can be considered the "direct cost." The corresponding loss of income from working days spent off recovering from pesticide exposure-related health problems can be considered as the "indirect cost." The health cost is calculated by adding the direct and indirect costs.

4.0 RESULTS AND DISCUSSION

4.1 Average Effect of VietGAP Program Participation on the Appearance of Health Symptoms on Farmers due to Pesticide Exposure

4.1.1 VietGAP program

Since 2010, the VietGAP program in Quang Thanh commune (Quang Dien district) has been operating using the organizational framework, technical support, and initial financial approval of the Department of Science and Technology, the Department of Agriculture and Rural Development, the Agricultural Extension Center, and Hue University of Agriculture and Forestry. Safe vegetable production has been practiced by household participants, agricultural cooperatives, and small business enterprises using the VietGAP program. To date, VietGAP production has been widely expanded among farmers in Quang Thanh via training courses and under the technical supervision of local agricultural cooperatives. The production process has strict regulations throughout—from input management for seeds, fertilizers, and plant protection products, to harvest management and waste management. All participants have attended training courses that explain every step of the production process from intensive cultivation, disease prevention, chemical use, harvest and postharvest techniques, to waste management, information-sharing meetings, and field experiments. Household participants who pass the strict technical regulations required for safe vegetable production according to VietGAP procedure standards receive certification. Through technical training courses and agricultural extension, an increasing number of farming households have been engaged in VietGAP procedures.

VietGAP production is different from conventional farming practices such that the former adopts a different set of standards and uses different types of fertilizers and pesticides that are environment-friendly. The production procedure must follow the technical criteria established by VietGAP in terms of input management for seeds, fertilizers, and plant protection products and in terms of harvest management and waste management (MARD 2008). Producing certified vegetable crops also require more labor and are subject to stricter regulations than the production of traditional crops do. Agricultural cooperatives and local governance play important roles in introducing, assisting, and encouraging farming households to adopt VietGAP standards by helping farmers via the provision of agricultural services and technical consultancy (Provincial Department of Science and Technology 2011).

The decision to participate in the VietGAP program can be associated with individual characteristics such as age, educational background, and production features of the land. Thus, measuring the health impact value of VietGAP program can potentially face the endogeneity problem of variables associated with VietGAP participation status. As such, the PSM method is essential when exploring the significance of factors associated with the probability of VietGAP program participation.

4.1.2 Individual factors associated with the probability of participation in the VietGAP program

The probability that a farmer would participate in the VietGAP program can be predicted based on certain factors, e.g., demographic characteristics, educational background, economic conditions, and production features. Table 1 proposes some related variables (and their definitions) that could affect the probability of VietGAP participation among farmers.

Table 1. Definitions of variables

Variables		Definition
Demographic characteristics	Gender	= 1 if respondent is female and 0 for male
	Age	= 1 if respondent is aged 25–35 years old
		= 2 for aged 35–45 years old
		= 3 for aged 45–55 years old
		= 4 for aged > 55 years old
Educational background	Education	= 1 if respondent has no schooling
		= 2 for primary school
		= 3 for secondary school
		= 4 for high school
		= 5 for university/college or higher
Economic conditions	Income	Monthly average income (million VND)
Production features	Area	Production area
	Cultivation experience	= 1 if cultivation experience is < 5 years
		= 2 for 5–10 years
		= 3 for 10–15 years
		= 4 for > 15 years
Training courses	Number of training courses on production safety farmers have attended in their local area	
VietGAP participation	VietGAP	= 1 if respondent has been participating in VietGAP program, 0 otherwise
Health problem appearance	Health problems	= 1 if respondent has health problems from exposure to pesticides, 0 otherwise

Gender and age variables belong to demographic characteristics, the education level variable measures educational background, and the income variable represents economic circumstances. Production features can (to some extent) be linked to the decision to engage in advanced production practices. Production area, cultivation experience, and the number of training courses on production safety represent the production features. Most of the variables are defined via scaling measurement. VietGAP program participation status and health problem appearance status are mentioned under binary variables.

The variables are statistically illustrated in Table 2. The relevant factors are shown in the classification of the VietGAP group of 77 farmers (the treatment group) and the conventional group of 123 farmers (the control group). In general, differences in the variables by participation program status could be found in age, education, cultivation experience, number of training courses undertaken on production safety, and health problem appearance.

Table 2. Statistical description

Variables	VietGAP Farmer				Conventional Farmer			
	Mean	Standard Deviation	Min	Max	Mean	Standard Deviation	Min	Max
Gender	0.12	0.32	0	1	0.28	0.45	0.0	1
Age	2.87	0.91	1	4	3.19	0.75	2.0	4
Education	2.88	0.74	2	4	2.11	0.87	1.0	5
Income	2.86	0.85	1	5	2.96	1.13	0.5	6
Area	1.70	0.56	1	3	1.99	0.88	1.0	5
Cultivation experience	2.78	0.77	2	4	2.38	0.95	1.0	4
Training courses attended	3.01	1.25	0	4	2.44	1.25	0.0	4
Health problems	0.05	0.22	0	1	0.44	0.50	0.0	1
No. of observations	77				123			

As seen from the mean value, VietGAP farmers tend to be younger, a higher proportion of them are male, they tend to have achieved a higher educational level, have more cultivation experience, and have attended a greater number of training courses on production safety than conventional farmers do. Smaller production areas, mainly under parcel management, are more popular among VietGAP farmers than conventional farmers. The detailed statistical significance of difference could be obtained by the t-test used in the next section. Economic circumstances were not significantly different between the two groups.

Table 3 shows that younger farmers with higher level of education and with more experience of cultivation have a 30% higher probability of joining the VietGAP program than older farmers. Younger farmers also have higher willingness to change their production practices to incorporate more up-to-date agricultural science. We also found that an increase in the educational level of farmers resulted in a 60% increase in involvement in the program. Farmers who have higher level of education tend to be more flexible in their approach to participating in technical training, found it easier to adapt to new production methods, and paid more attention to protection procedures that benefit health, as compared to farmers with less education. Cultivation experience, in particular, is a critical determinant for farmers wishing to participate in the safe production of vegetables. Results show that the group of farmers with more experience has a 48% higher probability of engaging in the VietGAP program than farmers with less experience. Farmers with a senior level of cultivation experience and more accumulated cultivation skills are preferable for involvement in the VietGAP program than farmers of a junior level. The farmer who attends more training courses has a 26% higher probability of participating in the VietGAP program.

Table 3. Factors associated with the probability of VietGAP participation

Factors/Determinants	Probability of VietGAP Participation	
	Coefficient	Standard Error
Gender	-0.21	0.28
Age	-0.30**	0.15
Education	0.60***	0.13
Income	0.07	0.19
Area	-0.45	0.26
Cultivation experience	0.48***	0.14
Training course	0.26***	0.09
Pseudo R^2	0.26	
Number of observations	200	

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

In summary, the VietGAP program is more relevant to farmers with higher educational background, longer experience of cultivation, and higher attendance at training courses on production safety. Gender, area of land under cultivation, and income are not significant when determining VietGAP program participation.

In addition to age, educational background, cultivation experience, and number of training courses attended, we also considered the size of a farmer's production area and whether this could impact directly or indirectly on pesticide exposure-related health problems. "Production area" refers to the level of resource investments such as time and/or labor spent on agricultural production; this can increase exposure to pesticides, which can lead to health problems.

4.1.3 Average effect of VietGAP program participation on health

This research aims to explore whether there was any significant difference between the health status of VietGAP farmers and that of conventional farmers. Observable factors, to some extent, can affect the selection of VietGAP program participation. As clarified previously, some factors are found to be different between the two groups. By using a t-test, the mean values of the variables gender, age, educational level, area of land under cultivation by one farmer, cultivation experience, and number of training courses on production safety are realized to have a statistical difference between the treatment group (i.e., VietGAP farmers) and control groups (i.e., conventional farmers) at the 5% level. The results of the t-test reaffirm the selection features of the VietGAP program since participation is more attractive to younger people with a higher educational background, longer experience of cultivation, and a lower rate of exposure to pesticides.

Since some factors have statistically significant differences between VietGAP farmers and conventional farmers, the balancing test from Table 4 aims to satisfy the conditional independence of the PSM method by creating a homogenous sample between VietGAP participants and matched conventional participants. This study employed the techniques of nearest neighbor matching, caliper and radius matching, kernel matching, and local linear regression matching. The balancing test guarantees that the mean values of explanatory variables between the two groups have no statistically significant difference. Therefore, the self-selection feature of the VietGAP program participation (considered an endogeneity problem) could be ultimately eliminated from this process. Accordingly, the measurement of the causal effect of the VietGAP program on health problems due to pesticide exposure among farmers could be obtained more precisely.

After the balancing test, the above techniques of the PSM method were implemented to obtain ATT. ATT measures the causal effect of VietGAP program participation on the health problems experienced by farmers due to pesticide exposure. The results from the four matching techniques, shown in Table 5, simultaneously show the significant impact of VietGAP program participation on health with statistical significance at the 1% level in nearest-neighbor matching, caliper and radius matching, kernel matching, and local linear regression matching.

In terms of ATT, the evidence derived from the four types of matching proves that participating in the VietGAP program lowers the probability of health problems due to pesticide exposure by 15.6% (nearest-neighbor matching), 22.9% (caliper and radius matching), 25.5% (kernel matching), and 23.6% (local linear regression matching). The positive effect of the VietGAP program on the health of farmers is significant for policy makers, who should provide and broaden incentives for farmers to move production behavior toward environment-friendly procedures in order to increase health protection and improve food safety.

Table 4. Balancing test

Variables	Parameters	Before Matching	After Nearest Neighbor Matching	After Caliper and Radius Matching	After Kernel Matching	After Local Linear Regression Matching
Gender	Mean (treated)	0.120	0.12	0.12	0.12	0.12
	Mean (controls)	0.280	0.13	0.13	0.10	0.13
	t-test (P-value)	0.007***	0.81	0.87	0.81	0.81
Age	Mean (treated)	2.870	2.87	2.87	2.87	2.87
	Mean (controls)	3.190	2.87	2.89	2.88	2.87
	t-test (P-value)	0.008***	1.00	0.91	0.93	1.00
Education	Mean (treated)	2.880	2.88	2.88	2.88	2.88
	Mean (controls)	2.110	2.78	2.86	2.83	2.78
	t-test (P-value)	0.000***	0.43	0.84	0.70	0.43
Income	Mean (treated)	2.860	2.86	2.86	2.86	2.86
	Mean (controls)	2.960	2.81	2.88	2.84	2.81
	t-test (P-value)	0.500	0.74	0.90	0.90	0.74
Area	Mean (treated)	1.700	1.70	1.70	1.70	1.70
	Mean (controls)	1.990	1.66	1.73	1.71	1.66
	t-test (P-value)	0.011**	0.68	0.72	0.97	0.68
Cultivation experience	Mean (treated)	2.780	2.78	2.78	2.78	2.78
	Mean (controls)	2.380	2.99	2.89	2.94	2.99
	t-test (P-value)	0.002***	0.11	0.42	0.23	0.11
Training courses undertaken	Mean (treated)	3.010	3.01	3.01	3.01	3.01
	Mean (controls)	2.440	2.81	2.77	2.78	2.81
	t-test (P-value)	0.002***	0.30	0.22	0.25	0.30

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5. Average effect of farmers' participation in VietGAP program on the appearance of health symptoms on farmers due to pesticide exposure

Attributes	Nearest-Neighbor Matching		Caliper and Radius Matching		Kernel Matching		Local Linear Regression Matching		
	Mean (treated)	Mean (controls)	Diff	Mean (treated)	Mean (controls)	Diff	Mean (treated)	Mean (controls)	
ATT	0.052	0.208	-0.156***	0.052	0.281	-0.229***	0.052	0.307	-0.255***
No. of observations	200								

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.2 Health Impact Value of VietGAP Program

As noted earlier, symptoms of health problems due to pesticide use in crop production are described through the appearance and severity of health problems caused by pesticide exposure (Table 6). The severity of health problems due to pesticide exposure denotes the economic value of health impact. As mentioned in the previous sections, the health impact value of the VietGAP program is defined as the difference in the economic value of the health problems experienced by VietGAP farmer group and that of the conventional farmer group.

Table 6. Presence of health problems due to pesticide exposure

Health Problems due to Pesticide Exposure	Proportion of Appearance (%)	
	VietGAP Farmer Group	Conventional Farmer Group
Skin irritation	1.30	31.71
Eye irritation	1.30	23.58
Mouth sores	0.00	31.71
Breathing difficulties	0.00	18.70
Headaches	2.60	25.20
Stomach discomfort	0.00	0.81
Fever	0.00	8.13
Muscle weakness	1.30	12.20
Others	1.30	2.44

For types, signs, and symptoms of ill health, note that health problems due to pesticide exposure can take on many forms but can usually be observed and are often immediate. In terms of severity, most of these health problems have short-term effects and are moderate in frequency.

Conventional farmers experience more health problems than VietGAP farmers do. We found that 31.71% of the conventional farmer respondents, compared to the 1.30% of VietGAP farmer respondents, experience skin irritation (e.g., light redness or rash) after spraying chemical pesticides. Skin irritation often happens because farmers do not wash their hands carefully after handling pesticides. Due to this direct exposure, 23.58% of the conventional farmer respondents and 1.30% of the VietGAP farmer respondents reported that their eyes had been affected due to pesticide exposure. Pesticide contamination of the skin and eyes increases when farmers use unprotected equipment and spray during windy weather conditions. The effects of pesticides in the forms of mouth sores, breathing difficulties, stomach discomfort, and fever only appear in the conventional farmer group. The negative impact of pesticide exposure on the oral tract causes mouth sores in 31.71% of the conventional farmers (different levels of pain are experienced). Pesticide exposure to the oral tract can occur when farmers do not wash their hands before eating and smoking or when farmers accidentally eat food with pesticides. At a higher level of seriousness, pesticide use can also immediately impact the respiratory tract, causing difficulty in breathing or impaired functioning of the lungs in 18.70% of the conventional farmers. Pesticides can also be inhaled when farmers spray in an air-conditioned space and when the pesticide mixes with dust. In addition, using cheap respirators increases the possibility of inhalation exposure. Headaches tend to be more prevalent in farmers involved in conventional production (25.20%), as opposed to 2.60% of VietGAP farmers. Noticeably, stomach discomfort and fever seldom appears, accounting for only 0.81% and 8.13% of conventional farmers. Muscle weakness occurs in both groups, with 12.20% of conventional farmers and 1.30% of VietGAP farmers experiencing this symptom. Fortunately, no farmers involved in our survey were experiencing serious disease due to pesticide exposure, such as hepatic dysfunction, nephrotoxic effects via changes in the liver and kidneys, and oxidative stress via the nervous system. From the comparative results shown in Table 6, conventional farmers have more diverse signs and symptoms of health problems than VietGAP farmers. In other words, it can be concluded that the VietGAP program has improved the health status of farmers who follow the program's guidelines.

The health cost was measured in this study to determine the health impact value of the VietGAP program. Expenses include the cost of medicine, income loss due to working days spent visiting the commune health center, and travel cost spent to go to health centers to treat or reduce health problems due to pesticide exposure; these constitute the direct cost. The corresponding income loss due to missing several working days to recover from the symptoms is an indirect cost. The health cost, measured in monetary terms, is calculated by adding the direct and indirect costs.

In this study, the health impact value of the VietGAP program was measured through the difference in the economic value of the health impacts between conventional production and VietGAP production; in other words, the difference in health cost estimation between VietGAP farmers and conventional farmers. The health impact value of the VietGAP program was recognized as the economic value of health status improvement toward environment-friendly production practices. Note that the health problems were only derived through farmers' exposure to pesticides; health problems due to other activities were excluded in the estimation.

As mentioned above, health problems from pesticide exposure are typically visible and immediate, e.g., skin irritation, eye irritation, mouth sores, and headaches. If the health problem is not serious and if the farmer is in a rural area, then symptoms are often left to heal naturally. In more serious cases, farmers visit the commune health centers or go to pharmacies to seek medicine that can ease their symptoms. Farmers rarely go to hospitals when the symptoms are mild, due to hesitant attitudes, and due to limited financial resources. Since conventional farmers suffer more symptoms and have more serious health problems, their direct health cost from pesticide exposure is estimated to be higher at VND 258,630 per farmer per year, compared to that of VietGAP farmer group at only VND 15,220 per farmer per year (Table 7).

Table 7. Health impact value of VietGAP program participation (in VND)

Health Cost	VietGAP Farmer Group (VND/farmer/year)	Conventional Farmer Group (VND/farmer/year)
Direct cost	15,220	258,630
Indirect cost	15,580	294,040
Total cost	30,800	552,670
Health impact value	521,870	

After each incidence of pesticide spraying, some farmers are still able to continue working; others need about half a day to recover and to treat the symptoms induced by pesticide exposure. Conventional farmers take about 3–7 days off annually to recover from health problems induced by pesticide exposure. VietGAP farmers take about 1–3 days off (if any). In conventional production, the estimated income loss due to loss of working days is calculated to be VND 294,040 per farmer per year. In VietGAP production, the indirect cost would only be around VND 15,580. Therefore, the derived health impact value of the VietGAP program is estimated to be VND 521,870 per farmer per year.

This significant difference in monetary value between VietGAP and conventional farmers should be justification enough to encourage conventional farmers to switch production methods.

4.3 Farmers' Individual Perceptions of Pesticide Hazards and Their Corresponding Precautionary Behavior

VietGAP production is a new and advanced method of production; a number of local farmers have been applying to enter the program since 2010 (after participating in the appropriate training courses). Therefore, before this research was conducted, these farmers have had between four and five years of VietGAP production experience. In this study, 200 farmers were selected from the three districts that play a vital role in the provision of vegetables. The production methods used by these farmers either comply with VietGAP inputs of fertilizers and pesticides or do not—the farmers using conventional methods of production were free to choose whatever inputs they can use. In spite of similar levels of productivity and economic efficiency, the VietGAP products were preferable in terms of their environment-friendly credentials.

Generally, although most local farmers are aware of the toxicity of pesticides, most of them still use such chemicals in order to maximize their profits from vegetable production. Table 8 describes the incidence of pesticide exposure among the farmers surveyed in this study. About 89.5% of the farmer respondents used pesticides. Noticeably, 32.5% of the respondents have contact with pesticides more than 24 times a year. Most of these farmers engage in conventional production.

Table 8. Incidence of pesticide exposure

Incidence	No. of Households	Percentage (%)
Exposure	179	89.5
1–8 times	12	6.0
8–16 times	46	23.0
16–24 times	56	28.0
> 24 times	65	32.5
Non-exposure	21	10.5
Total	200	100.0

The survey also investigated whether or not the farmers at the sampling sites use protective gears during pesticide spraying (Table 9). Among the 179 households in contact with pesticides in vegetable production, our findings show that 64.2% of them prepare and use protective equipment. About 21.8% of those who do not use protection equipment said that using such is “unnecessary.” Some of the respondents (9.5%) said that it is “inappropriate” to use protection equipment. The remainder of respondents (3.4%) said that it is “uncomfortable” to use protection equipment. Therefore, 35.8% of farmers do not prepare and use protective equipment when using pesticides.

Table 9. Use of protective equipment when spraying pesticides

Protection Equipment Use	No. of Households	Percentage (%)
Do not prepare	64	35.8
– because uncomfortable	6	3.4
– because inappropriate	17	9.5
– because unnecessary	39	21.8
– all of the above	2	1.1
Do prepare	115	64.2
Total	179	100.0

We used the Likert scale to evaluate farmers’ perceptions of the hazards of pesticides and the necessity for protection equipment. A score of 1 represents “very disagree,” 2 is “disagree,” 3 is “normal,” 4 is “agree,” and 5 is “very agree” (Table 10). The results revealed the fact that most farmers understand the health risks posed by pesticide use, as indicated by the score of 4.2 on the Likert scale. However, because farmers aim to maximize their profits, most conventional farmers use excessive amounts of pesticides, thus increasing the possibility health problems. In theory, these farmers believe that using protective gears is important (score: 4.1). In practice, however, the preparation and use of protective equipment is still a controversial issue because farmers who have been cultivating for a long time think that if they are careful, they can avoid the toxicity of pesticides. This kind of attitude causes soil, water, and air pollution, and has detrimental health effects. Another issue is that some farmers use low-quality protective equipment in their production. Low-income farmers do not invest in high-quality products—they usually buy products at the lowest price. In addition, when the protective equipment gets damaged, farmers still tend to use and recycle them. Therefore, using protective equipment does not necessarily reduce the health risks faced by farmers.

Given the health and environmental benefits of the VietGAP program, this study used the Likert scale to investigate VietGAP farmers’ comments on the VietGAP program (Table 11). Similarly, a score of 1 represents “very disagree,” 2 is “disagree,” 3 is “normal,” 4 is “agree,” and 5 is “very agree.”

Table 10. Farmers' awareness of pesticide hazards and their health protection skills

Statements	Min	Max	Mean	Standard Deviation
Pesticides harm the health of farmers during spraying	3	5	4.2	0.77
Protection equipment is necessary for farmers to protect their health	3	5	4.1	0.77

Table 11. VietGAP farmers' comments on the VietGAP program

Statements	Min	Max	Mean	SD
Farmers' health improved when they participated in the VietGAP program	3	5	3.7	0.71
Farmers' knowledge on safe vegetables increases due to VietGAP program	3	5	3.5	0.55
Farmers become more aware of the harmful effects of pesticide exposure to health due to the VietGAP program	3	5	3.4	0.53
VietGAP is a good method of planting vegetables in Thua Thien Hue	2	5	3.4	0.62

Table 11 shows that nearly all farmer respondents agree that the VietGAP program has improved the health status of farmers (score: 3.7). Likewise, they agree that farmers' knowledge on environment-friendly production enhanced (score: 3.5) due to the program. The evaluation method of the VietGAP program scored 3.4. From the focus group discussions, this could be explained by the limitations of the asynchronous plan in production, as well as weak market power, weak market confidence, and a shortage of consumption. Therefore, the efforts of synchronous expansion in production planning, market efficiency enhancement in the supply chain, and an increase in confidence for local consumers are vital instruments for further development of the VietGAP program in Thua Thien Hue province.

5.0 CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Conclusions

This study measured the health impact value of the VietGAP program on farmers in Thua Thien Hue province, Vietnam. The VietGAP program provides standard types and uses of fertilizers and pesticides. Most VietGAP pesticides originate from biological products, and pesticide use is strictly regulated. VietGAP production procedure follows a particular set of technical criteria in terms of input management for seeds, fertilizers, plan protection products, harvest management, and waste management. Health attributes during production are described through the appearance and the economic value of the health problems resulting from exposure to pesticides.

Results of this study show that after nearly five years of VietGAP's implementation, the program has significantly improved the health status of local VietGAP farmers. Since VietGAP participation can be assigned from observable factors, we used the PSM method to obtain the average causal effect of VietGAP program participation on the health problems experienced by farmers due to pesticide exposure. The findings imply that VietGAP program participation is significantly associated with the farmer's age, educational background, cultivation experience, and incidence of pesticide exposure. After applying a balancing test to treat the self-selection feature and endogeneity problem of VietGAP program participation, results proved that participating in the VietGAP program significantly lowers the probability of pesticide exposure-related health problems by 15.6%, 22.9%, 25.5% and 23.6% using the methods of nearest-neighbor matching, caliper and radius matching, kernel matching, and local linear regression matching, respectively. The VietGAP program has moved farmers toward environment-friendly production methods that provide greater health protection and environmental sustainability. The positive health impacts of the VietGAP program are expected to encourage farmers to change their production behaviors.

Most of the health problems experienced by the farmers at the study sites are short-term and moderate in incidence. Conventional farmers experience more symptoms; their symptoms are likewise more severe than those experienced by VietGAP farmers. Based on the survey results, 32% of the conventional

farmer respondents suffer from skin irritation and mouth sores; 24% from eye irritation; 25% from headaches; 19% from breathing difficulties during or after spraying pesticides; 8% from light fever; and 12% from muscle weakness. Meanwhile, health problems due to pesticide exposure rarely appear among VietGAP farmers. Only 1%–3% of the VietGAP farmer respondents suffer from skin irritation, eye irritation, headaches, and muscle weakness due to pesticide exposure.

In terms of the cost of health problems due to pesticide exposure, this research estimated the economic value of the improvement in health status of the local farmers in Thua Thien Hue due to their participation in the VietGAP vegetable production to be VND 521,870 per farmer per year.

Overall, the VietGAP vegetable production is a good program for promoting environment-friendly production for farmers. However, this production strategy still faces a number of development challenges. Therefore, it is necessary to implement initiatives that would enhance the market for safe vegetables, reinforce consumer confidence toward the product, and ensure high-quality crop production management. These vital instruments would help the development of the VietGAP vegetable production in Thua Thien Hue province.

5.2 Policy Implications

5.2.1 Production-related solutions

The production area under the VietGAP program should be extensively and intensively broadened in tandem with rural development programs aimed at enhancing the value of traditional activities. Production processes should improve the quality of inputs, especially seeds and fertilizers, to increase crop productivity and increase value added. The use of permitted biological products should also be promoted in production and pest management. Likewise, education among farmers with regard to pesticide safety should be expanded. The government should also promote the use of quality-guaranteed protection equipment when using pesticides in crop production. In connection with this, farmers should avoid using excessive amounts of chemical pesticides that harm their health.

The types of vegetables grown should also be diversified. Farmers should also consider investing in those vegetable varieties that can adapt to local conditions, have a high commodity value, and have high economic efficiency. Moreover, farmers need to ensure the quality of their products; once farmers guarantee the quality and quantity of the commodities they market, the promotion of safely produced vegetables can take place.

5.2.2 Consumption-related solutions

In Thua Thien Hue, VietGAP products face difficulties regarding market access. A large volume of vegetables are produced via conventional farming methods, and these dominate the market. Vegetables produced via VietGAP are not as popular because they are relatively more expensive—they cost 10%–20% more than conventionally produced food products.

VietGAP produce also faces competition from products inside and outside Thua Thien Hue province. The traditional consumption habits of consumers ensure that local people buy food on a daily basis at the most convenient location, at the most convenient time, at the best price, and with scant regard as to whether the products are guaranteed by a particular certification or source. The weakness lies in the inability to promote safe vegetables at designated places (such as supermarkets), thus limiting their purchase.

VietGAP farmers also need to sell their produce in the same way that conventional farmers do because they can't preserve vegetables for long after harvesting. Therefore, a systematic and effective supply chain for safe vegetables needs to be developed; this needs considerable technical and financial investment in the production process and distribution channels.

Consumption solutions should be oriented toward setting up guaranteed outlets at local markets and within supermarkets where safe vegetables can be sold. Some customers agree that safe vegetables should cost more, even 20%–25% more, but they also want their quality to be guaranteed and to be accessible for purchase. Likewise, local officials should enhance community perceptions of safe vegetables and encourage their consumption as part of health improvement.

Consumers' confidence on safe vegetables plays an important role in the promotion of VietGAP products. Once consumers gain confidence in locally produced safe food products, it is expected that they will engage in better consumer behaviors. Women are usually the decisive actors in choosing and preparing a family's food—their consumer behavior affects the quality of food a family eats every day and, therefore, the family's long-term health. Accordingly, housewives' knowledge on environment-friendly food products should be improved in order to bring positive impacts on family health. Marketers should also provide incentives to improve the advertising of safe food via the mass media, with the aim of broadening the safe food trademark and increasing confidence in locally produced safe food products.

5.2.3 Management-related solutions

Quality assurance should be promoted in terms of packaging, trademark, and price point in order to increase the value of safe food products. In transporting vegetable commodities, quality assurance should be guaranteed to safeguard the freshness of safe food products. Local officials and academies should improve the provision of technical assistance to improve quality assurance. Training courses should aim to transfer the skills needed to change cultivation methods and should provide guidance in using fertilizers and plant protection instruments, monitoring the harvest, and monitoring the final product. Local governors and agricultural cooperatives should engage in quality assurance of inputs, the production process, and the supply chain under the assigned criteria in order to move forward to health protection for communities.

LITERATURE CITED

- Asfaw, S.; D. Mithöfer; and H. Waibel. 2009. Food safety standards and farmers health: Evidence from Kenyan's export vegetable growers. Presented at the International Association of Agricultural Economists Conference, 16–22 August, 2009, Beijing, China. International Association of Agricultural Economists, Milwaukee, WI.
- Atreya, K. 2008. Health costs from short-term exposure to pesticides in Nepal. *Social Science & Medicine*. 67(4): 511–519.
- Becker, S.O. and A. Ichino. 2002. Estimation of average treatment effects based on propensity scores. *The State Journal*. 2(4): 3458–377.
- Dasgupta, S.; B. Laplante; H. Wang; and D. Wheeler. 2002. Confronting environmental Kuznetz curve. *Journal of Economic Perspectives*. 16(1): 147–168.
- Dung, N. and T. Dung. 1999. Economic and health consequences of pesticide use in paddy production in the Mekong Delta, Vietnam. EEPSEA Research Report Series: February 1999. Economy and Environment Program for Southeast Asia, Singapore.
- FAO (Food and Agriculture Organization) 2010. International code of conduct on the distribution and use of pesticides: Guidance on pest and pesticide management policy development. FAO, Rome, Italy.
- Hashmi, I. and K.A. Dilshad. 2011. Chapter 8: Adverse health effects of pesticide exposure in agricultural and industrial workers of developing country. M. Stoytcheva (ed.) *In Pesticides – The impact of pesticide exposure*. InTech, Rijeka, Croatia.
- Health Ministry of Vietnam. 2012. Report of food poison cases from 2007 to 2011. Food Safety Division, Health Ministry, Hanoi, Vietnam.
- Hurtig, A.K.; M.S. Sebastian; A. Soto; A. Shingre; D. Zambrano; and W. Guerrero. 2003. Pesticide use among farmers in the Amazon Basin of Ecuador. *Archives of Environmental Health*. 14(58): 223–228.
- MARD (Ministry of Agriculture and Rural Development). 2008. Good agricultural practices for production of fresh fruits and vegetables in Vietnam. Agricultural Publishing House, Hanoi, Vietnam.
- Ngan, P.B. and D.X. Thang. 2006. The influence of pesticides on the sprayer's health. *Science & Technology Development*. 9(2).
- Provincial Department of Science and Technology. 2011. Report for GAP implementation. Provincial Department of Science and Technology, Vietnam.
- Pufahl, A. and C.R. Weiss. 2008. Evaluating the effects of farm programs: Results from propensity score matching. Presented at the 107th EAAE Seminar: Modelling of Agricultural and Rural Development Policies, 29 January to 1 February, 2008, Sevilla, Spain. European Association of Agricultural Economists, The Hague, The Netherlands.
- Rola, A.C. and P.L. Pingali. 1993. Pesticides, productivity, and farmers' health: An economic assessment. International Rice Research Institute, Laguna, Philippines.
- Rola, A.C.; F.H. Roquia; A.R. Chupungco; and J.T. Hernandez. 1998. Pesticides, food safety, and the environment: Socio-cultural, economic concerns, and policy adjustments. Center for Policy and Development Studies, University of the Philippines Los Baños, Laguna.
- Rosenbaum, P. and D.B. Rubin. 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika*. 70(1): 41–55.

- Simmons, L. and S. Scott. 2007. Health concerns drive safe vegetable production in Vietnam. *Leisa Magazine*. 23(3): 22.
- Uematsu, H. and A.K. Mishra. 2011. Are organic farmers really better off than conventional farmers? Presented at the 2011 AAEA & NAREA Joint Annual Meeting, 24–26 July, 2011, Pittsburgh, Pennsylvania. Agricultural and Applied Economics Association, Milwaukee, WI.
- Wooldridge, J.M. 2001. *Econometric analysis of cross section and panel data*. 1st ed. The MIT Press, Cambridge, MA.

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