The GAP program and its effects on pesticide use in Damnoen Saduak, Ratchaburi, Thailand.

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Doctoral Dissertation

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2015

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Chapter 1
Introduction

1.1 Thailand as an Exporter of Fruits and Vegetables

For many developing countries, agriculture represents not only a source of food for the population but also a main source of income and employment, making it a key factor in economic expansion (Kasem and Thapa, 2012). Thailand in particular has become one of the most important worldwide exporters of processed food and agricultural products including tropical fresh fruits (Fig. 1) (Panuwet *et al.*, 2012). In 2011, the population of Thailand was estimated as 67 million, with a labor force up to the same year of about 60% of the total population, of which more than 40% were engaged in the agricultural sector (Wannamolee, 2008; Konuma, 2012). By 2012, the agricultural area of Thailand had reached 21,860,000 ha (FAOSTAT, 2014).

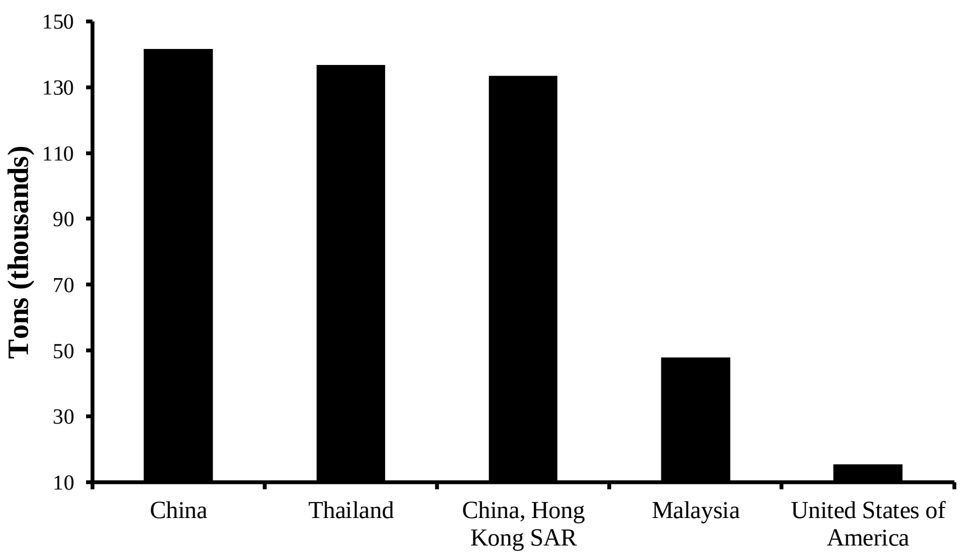

Fig. 1. Largest exporters of tropical fresh fruits. Average production for 2000-2010. Source: FAOSTAT, 2014

Thailand’s most important food products are rice, rubber, cassava, sugar, fruits, oil seeds, vegetables, canned tuna, shrimp products, and livestock (Figs. 2 and 3 show the data for fresh fruits and vegetables, respectively). Rice production reached about 35 million metric tons in 2010, making Thailand the main exporter of rice in the world market. On average, 8.5 million tons per year contribute to the net export earnings of approximately 120 billion baht (Konuma, 2012; Panuwet *et al.*, 2012). The economy of Thailand is highly dependent on export, which account for approximately 70% of the GDP, and in 2012, exports from Thailand were estimated to be worth 16,630 million USD.

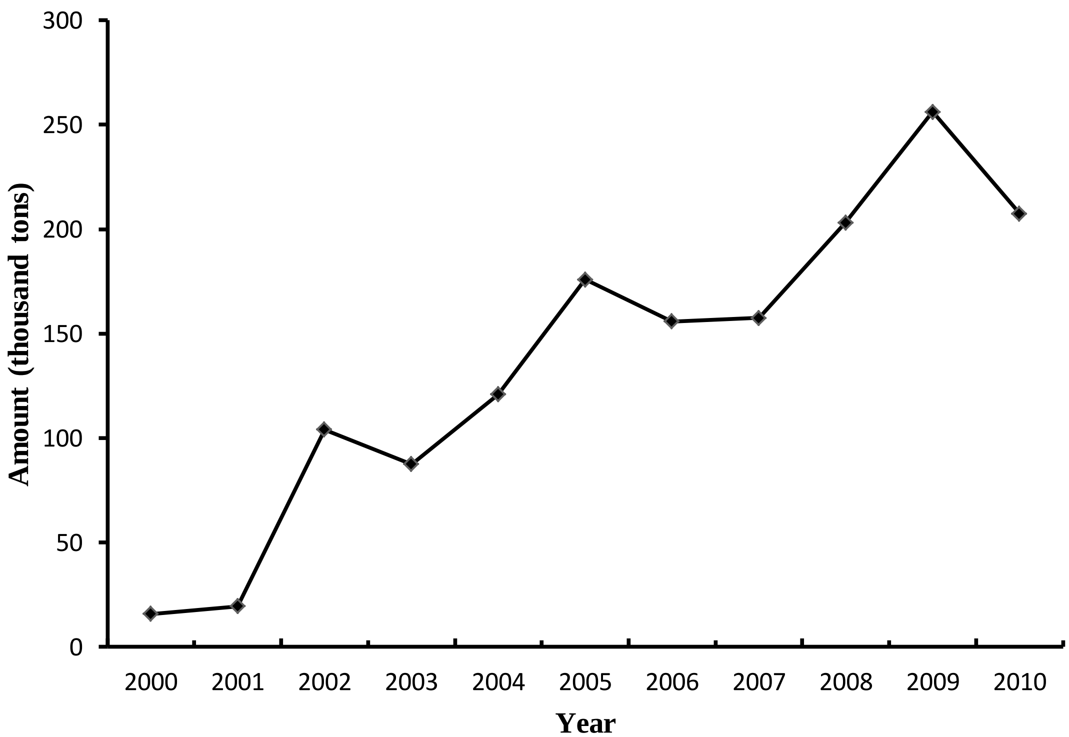

Fig. 2. Export of tropical fresh fruits from Thailand during the period 2000-2010. Source: FAOSTAT, 2014

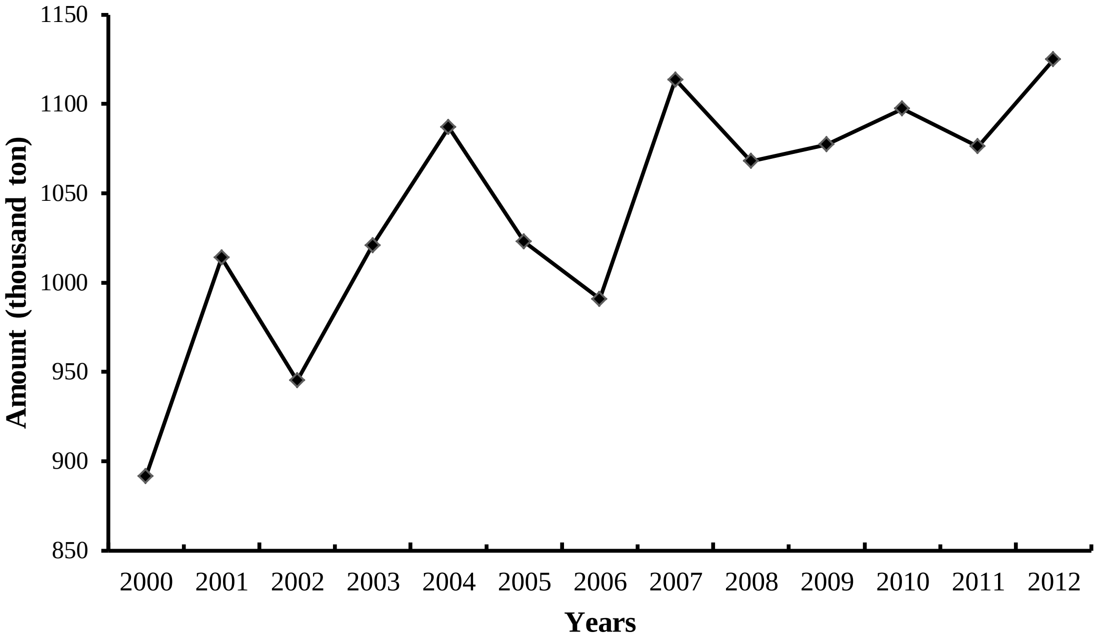

Fig 3. Fresh vegetable production in Thailand 2000-2012.

Source: FAOSTAT, 2014

During the past few decades, Thailand has shown remarkable economic progress, with an estimated reduction in national poverty from 34% in 1992 to 8.1% in 2009. The annual per capita GDP growth rate reached 8% in 2012, and in 2001 Thailand was upgraded from a middle-income to an upper-middle income country by the World Bank. In 2013, the country had a medium human development rating of 0.690 on the Human Development Index and was ranked 103 out of 187 countries (UNDP, 2013). Undoubtedly, all this progress resulted in Thailand being ranked the second largest economy in Southeast Asia after Indonesia (Konuma, 2012).

However, estimates of the effect of growth-oriented agricultural policies have shown that intensive food production and the implicit economic growth in countries such as Thailand has been achieved at the detriment of the environment and natural resources, which are necessary for the sustainability of agro-ecosystems (Rigg, 1995; Kasem and Thapa, 2012). Impacts of agricultural augmentation reported by the United Nations Environment Program include soil contamination, deforestation, and misuse of inorganic fertilizers and pesticides (Clarke *et al.*, 2002).

The use of synthetic pesticides in Thailand serves as an efficacious tool for crop protection, helping satisfy the demands of the global food market by increasing the level of production and improving the appearance and quality of the product (HSRI, 2005; Panuwet *et al.*, 2012). In the absence of food and plant protection programs, about 50% of crops can be lost as a result of pests and diseases (Oerke and Dehne, 2004).

With agricultural expansion, pesticide use in Thailand has increased significantly during the last decade, with more active ingredients being imported into the country each year (Fig. 4). In 2010 alone, 70,000 tons of pesticides were imported, the most abundant of which were chlorpyrifos, fenobucarb, cartap hydrochloride, cypermethrin, and methomyl. The most imported herbicides were glyphosate, paraquat dichloride, 2,4-D, ametryn, and atrazine, while the most imported fungicides were mancozeb, sulfur, carbendazim, promineb, and captan (OAE, 2010; OAR, 2011).

Subsequently, in 2005 Thailand was ranked fourth on a list of 15 Asian countries with the largest annual pesticide use, and third in terms of pesticide use per unit area (Walter-Echols and Yongfan, 2005). In face of such intensive pesticide use, the Government of Thailand has started to respond actively to the management of hazardous chemicals by issuing and executing its primary legal instrument (RTG, 1992, 2001, 2008), the Hazardous Substance Act, which up until 2012 concerned 1,233 chemicals (Panuwet *et al.*, 2012). Following the WHO Recommended Classification of Pesticides by Hazard, five pesticides imported into Thailand in 2010 were classified as Ia (extremely hazardous), 11 class Ib (highly hazardous), 95 class II (moderately hazardous), and the remainder either class III (slightly hazardous) or unlikely to present acute hazards in normal use (WHO, 2010). The consequences of chronic overuse and misuse of synthetic pesticides has led to the introduction of standards of good agricultural practices (GAP) in countries such as Thailand, with the aim of increasing food safety.

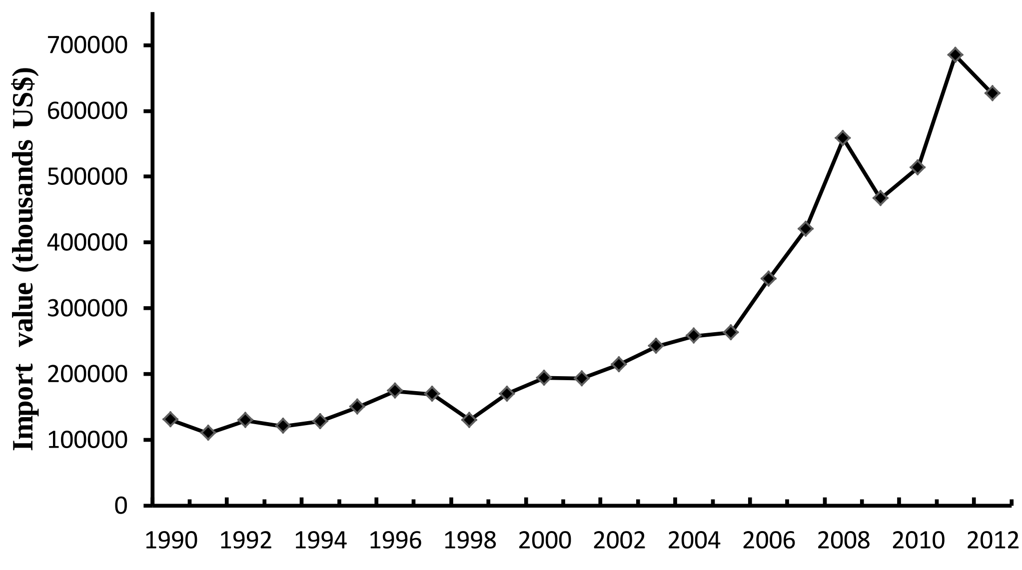

Fig. 4. Import value of pesticides imported into Thailand from 1990-2012. Source: FAOSTAT, 2013.

1.2 Development of the Good Agricultural Practices Program in Thailand

Food Safety is one of the most relevant global issues that has required the collaboration and cooperation of stakeholders at different levels across the world (Srithamma *et al.*, 2005). Protecting the health and safety of domestic consumers and assuring the safety and quality of food entering the international market is not only important, but requires standards conformable to national requirements (FAO/WHO, 2003).

At present, many countries, including Thailand, reinforce food safety in order to implement and enhance management systems and food safety supervision along the entire food chain; from production to processing, storage, and distribution (Henson and Humphrey, 2010). In Thailand, the production of tropical fruits and vegetables in particular face problems such as low production and post-harvest efficiency as well as the misuse of agrochemicals, especially pesticides. Consequently, negative effects on the environment, food safety, and human health are expected in the absence of programs that confront such problems. With the growing export of fruits and vegetables, and increasing demand from the foreign market, The Government of Thailand responded by declaring the year 2004 as "Thailand's Food Safety Year". Food safety policies were disclosed as a strategy to promote the quality of food produced for both export and domestic consumption. The "National Road Map of Food Safety" policy was developed as a guideline for related sectors and agencies at provincial and central levels, encouraging them to become involved in quality control at every stage of food production. At the farm level, the GAP program was established (Srithamma *et al.*, 2005; Wannamolee, 2008; Panuwet *et al.*, 2012).

This particular GAP program must not be confused with other GAP programs in implementation since the beginning of the 2000s in Thailand as well as other countries belonging to the Association of South East Asian Nations (ASEAN) and also intended to guarantee quality at the field level. The term GAP has been used in diverse contexts and based on diverse meanings. It is an approach that has been used not only in the international regulation framework, but also in the private sector and under voluntary and non-regulatory applications (Amekawa, 2013).

Most up-to-date literature on GAP focuses on GlobalGAP, formerly known as EurepGAP, the standard created in the late 1990s by a team of European retailers (The Euro-Retailers Produce Working Group (Eurep) with the aim of improving practices for the correct use of pesticides, and therefore, helping reduce the environmental impact of agriculture. This standard emphasized the implementation of integrated crop management methodologies and various integrated pest management practices (Konefal *et al.*, 2005; Amekawa, 2013). However, the implementation of GlobalGAP standards became problematic when certain groups of producers were excluded from the export sector due to the limitations of financial capital. As a counteraction to the GlobalGAP approach, public GAP standards were established during the early 2000s and advertised by ASEAN countries including Indon-GAP, Singapore GAP-VF, Malaysian SALM, Thai Q-GAP, and Philippine-GAP (Konefal *et al.*, 2005; Amekawa, 2013).

The public GAP standards promote the implementation of free extension and vigilance of GAP certification with the support of private and civic institutions in order to help small-scale producers accomplish better practices for safe production, lowering the environmental impact and reducing poverty, consequently promoting food safety domestically and internationally (Amekawa, 2009). In the framework of this thesis, only the public GAP approach (also referred to as Q-GAP, where ‘Q’ stands for ‘quality’) currently implemented in Thailand was examined.

In Thailand, the adoption of a public GAP program was managed by the Ministry of Agriculture and Cooperatives (MoAC) with the following objectives: to maintain consumer confidence in food safety and quality, assure growers safety, and reduce negative impacts on the environment. Furthermore, it also intended to expand Thailand’s agricultural exports, making the country more competitive in the international market by ensuring food quality and safety (Wannamolee, 2008; Amekawa, 2013).

Management of GAP certification is performed by three government parties belonging to the MoAC: administration by the Department of Agriculture (DoA): accreditation to provide certification by The National Bureau of Agricultural Commodity and Food Standards (ACFS), where certified products are labeled with the “quality” GAP logo Q; and lastly, GAP training and assistance via the Department of Agricultural Extension (DoAE). Every two years, farmers are required to go through a recertification process involving an official GAP inspector visit and formal interview. Eight aspects of production are the focus of these evaluations: water systems, overall condition of the farm, use of agrochemicals, storage and shipping of the product, the keeping of records, safety of the product, farm management, and lastly, harvest and post-harvest practices. All eight cover a wide range of farm management issues; however, the DoA clearly emphasizes the third aspect of food safety through the control of pesticide residues (Sardsud, 2007; Wannamolee, 2008; Schreinemachers *et al.*, 2012b).

Monitoring activities of the DoA consist mainly of crop and soil sampling, collected to be analyzed later by a regional laboratory center for pesticide remains. In order to obtain certification or recertification, farmers are required to go through this procedure a minimum of three times per year without notice in advance of sampling dates or times. Up until 2008, a total of 363,946 farms were registered and 169,886 farms were certified across Thailand. Additionally, 29 crops were designated as special crops for export and domestic consumption in the GAP standard (Sardsud, 2007; Wannamolee, 2008; Amekawa, 2009, 2013).

Some studies suggest that the GAP program is not being fully implemented in Thailand because, despite the attention given to food security in the final stages of food production through residue testing, limitations remain in terms of monitoring of pre-farm gate practices. Moreover, unsatisfactory results have been found with regards to the way the DoA presents alternative crop management techniques (Schreinemachers *et al.*, 2012b; Amekawa, 2013; Pongvinyoo *et al.*, 2014).

1.3 Study Objectives

The first objective of this study was to examine how fresh fruit and vegetable farmers certified with a GAP license (From now on GAP farmers) choose, use, and handle synthetic pesticides compared to those who are not certified (non-GAP farmers). The second was to quantitatively compare pesticide use between GAP and non-GAP asparagus farmers. The toxicity class of pesticides being used, the levels of synthetic pesticide use, the relationship between pesticide use and yield, and whether GAP certification provides economic benefits to farmers were assessed. The third objective was to examine the effect of the GAP program on levels of concern among asparagus farmers toward the negative effects of synthetic pesticide use on human health and the environment, and to assess the importance given by farmers (whether participating in the GAP program or not) to the DoAE and other sources of information on pest management. In general, with all three objectives, farmers following the GAP program were expected to use fewer and less hazardous pesticides, handle them in a safer way, show higher concern over the negative effects, and give greater importance to the DoAE as a source of information compared to their non-GAP counterparts.

Chapter 2
Description of study site

2.1 General characteristics of Damnoen Saduak

This study was conducted in Tha Nat and Damnoen Saduak, two contiguous Sub Districts of the Damnoen Saduak District (Fig. 5) in Ratchaburi Province, central Thailand. These two Sub Districts are located in a lowland region, where fruits and vegetables are produced intensively by means of a particular market-oriented agrarian system, where an old tidal marsh located in the Mae Klong basin has been polderised (western part of the Chao Phraya delta), standing in the fringes of more traditional rice-based systems.

The agriculture plots consist of raised beds that are part of a canal network that provides drainage and irrigation systems all along the year (Cheyroux, 2003).

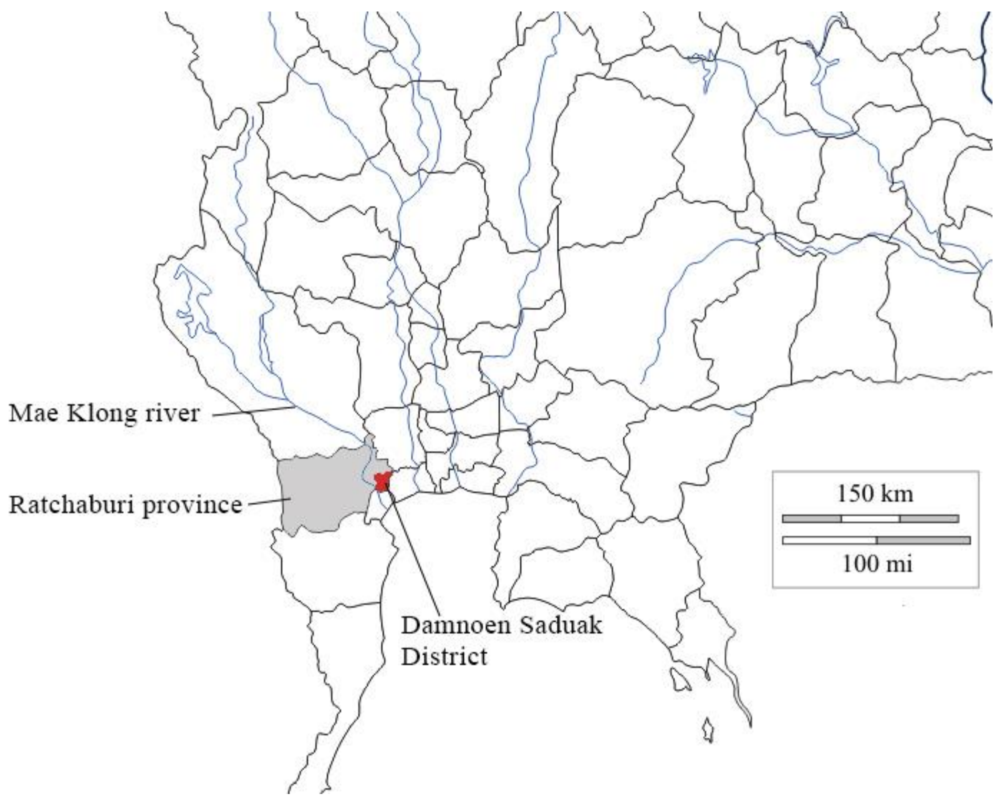

Fig 5. Damnoen Saduak in Central Thailand.

These beds alternate with ditches, in which water remains stagnant (Fig. 6). The crops planted on the beds are in most cases watered by the use of small boats which are led through the ditches and spray by means of a pump (Fig. 7) (Molle *et al.*, 1999).

Damnoen Saduak has very specific conditions that make it a singular region: an irrigation network, proximity to the Bangkok and an efficient chain of supply to different markets. It is possible to cultivate the raised beds all year long and some farmers opt for 3-4 cycles of annual crops, while others have established perennial plantations of fruit species. Intensification and diversification of cropping systems go hand in hand with the demand for fruits and vegetables in the growing urban centers (particularly Bangkok). The flow of goods is nowadays done by the road network that crosses the Mae Khlong delta (Cheyroux and Dufumier, 2006).

The intensification means that the high and frequent pesticide use is prevalent in the region which puts in risk the health of the producers and consumers, and can affect negatively the dense network of waterways and the adjacent land. These aspects might become an important problem for Damnoen Saduak which questions the sustainability of its agricultural development (Molle *et al.*, 1999; Cheyroux, 2003; Cheyroux and Dufumier, 2006).

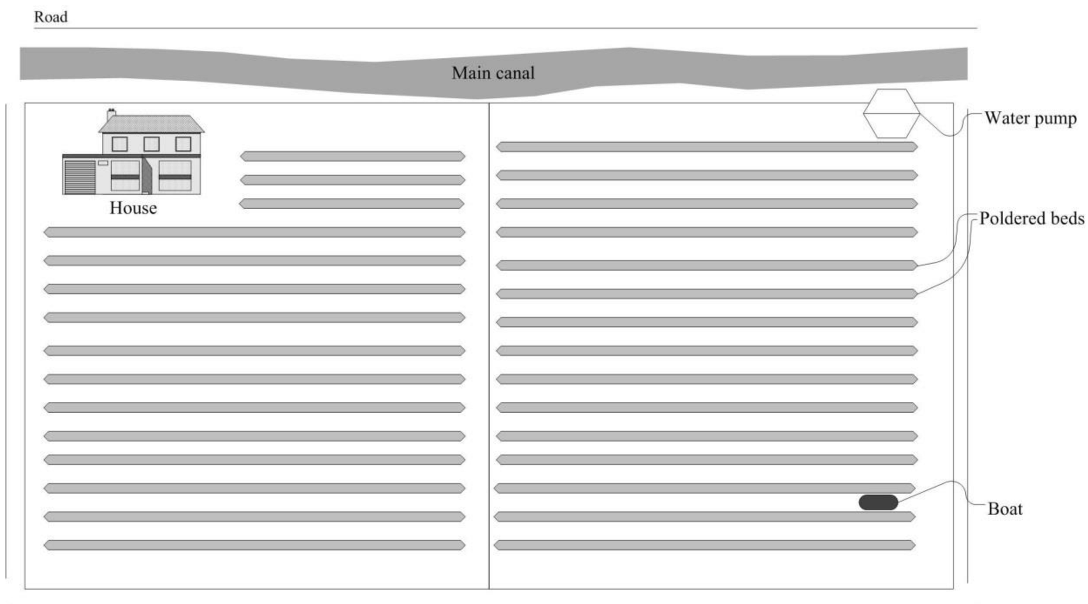

Fig. 6. Layout of a typical horticultural plot in Damnoen Saduak.

Fig. 7. Raised beds of and "baby corn" and asparagus in Damnoen Saduak.

Chapter 3
Do GAP farmers do better than non-GAP farmers? Pesticide management practices of horticultural farmers in Damnoen Saduak, Thailand.

3.1 Introduction

The GAP standard, also referred as Q-GAP where the letter Q stands for quality is based on eight farm related elements which must have been taken care of: Water sources, plantation area, pesticide application, quality management in pre-harvest, quality of harvest and post-harvest handling methods, holding of produce (moving and storage of produce within plantation), personal hygiene, and data recording and traceability (NBACFS, 2009). Given that the GAP program focuses on reducing synthetic pesticide use to produce safe food, it gives a clear emphasis on controlling the third element of this standard: "pesticide application" through the monitoring of pesticide residues on the produce (Sardsud, 2007; Wannamolee, 2008; Schreinemachers *et al.*, 2012b; Amekawa, 2013).

The Ministry of Agriculture and Cooperatives (MoAC), is the government's institution responsible for implementing the GAP program. Its National Bureau of Agricultural Commodity and Food Standards (ACFS) has designed the standard so that the agricultural practices incorporate the principles of Integrated Pest Management (IPM) (NBACFS, 2009) and its Department of Agriculture (DoA) is in charge of processing the GAP applications, providing certification after farmers pass the necessary inspection, and subsequently monitoring and auditing farmers practices for assuring an adequate implementation of the GAP standard (Wannamolee, 2008).

The DoA is also involved on the surveillance and evaluation of those pesticides that have a severe adverse impact on human health or the environment and it can take action to ban or severely restrict their use. Such is the case of methomyl, dicrotophos, aldicarb, blasticidin-S, carbofuran, ethoprophos, formetanate, methidathion, oxamyl, and ethyl p-nitrophenyl thionobenzenephosphonate (EPN) (Panuwet *et al.*, 2012). In the case of Cypermethrin and Abamectin, which are linked with the breakouts of pests in the country and elsewhere in Asia, it has developed campaigns to avoid their misuse (IRRI, 2011).

The responsible for conveying the pertinent pesticide related information to the farmers is yet another body of the MoAC, the Department of Agricultural Extension (DoAE), which provides GAP training and advisory services oriented to reduce synthetic pesticide use, and incorporation of alternative pest management techniques. The DoAE, being the government's agricultural extension agent, also provides training about these topics to non-GAP farmers (Sardsud, 2007; Wannamolee, 2008; Amekawa, 2013).

The study done in this chapter compares the practices of horticultural farmers to see if the GAP program has allowed them better opportunities to enter international markets and to see if the practices of those that are certified, are better in terms of improving food security and worker safety through adequate synthetic pesticide use. Farmers under the GAP program, were expected to opt to use less hazardous pesticides, handle them in a safer way and spray their crops less often (avoid preventive spraying). It was assumed that these aspects would be in relation with the GAP training and auditing received from the MoAC.

3.2 Research Context and Methods

Using structured questionnaires 86 randomly chosen horticultural farmers were interviewed in Damnoen Saduak Sub-District which has around 1,700 farming families. The first interviews were done during the period from

November 2012 to January 2013 to obtain general information about the type of crops being grown, the pesticides that were being used, the markets where they sold their produce and whether they were certified with a GAP license.

During the period from March to April 2013, a second structured questionnaire was used to compare GAP and non-GAP farmer's habits concerning the use of agrochemicals based on what is reported on the GAP Standard (Appendix). This time the sample was increased to include 130 farmers. In general, the interview covered questions about information collection, how they handled insecticides and fertilizers, the precautions they took when they sprayed and the training received from the Department of Agricultural Extension (DoAE) of the Ministry of Agriculture and Cooperatives (MoAC), the office responsible of providing extension services, GAP training and technical advice to the farmers (Sardsud, 2007).

To learn more about the GAP program implementation and verify some of the data collected through the questionnaires, some governmental officers from the DoAE were interviewed and asked about their duties and the limitations they faced.

Two tailed two samples mean comparison tests with unequal variances was used to detect significant differences between farmers' affirmative answers to questions related to methods of pest control, pesticide handling, protection gear and training received.

3.3 Results.

Table 1 shows a list of 9 common fruits and vegetables that were cultivated in Damnoen Saduak District, ordered in two groups: A and B. Group A includes those that were produced either for export to international and/or domestic markets, while Group B only includes the crops that were sold to domestic markets.

Only those crops reported as for export: asparagus, calamondin, rose apple and coconut were associated with farmers that were certified under the GAP program. Conversely, guava, pak kwan tung (one kind of Chinese cabbage), cucumber, lettuce and yard long bean were only associated with non-GAP farmers.

Table 1 also shows that the most frequently reported synthetic insecticides used by at least 10% of the farmers sampled, in descending order were: Methomyl, Abamectin, Cypermethrin and Chlorpyrifos. Methomyl is classified by the World Health Organization (WHO) as Class Ib “highly hazardous” pesticide. Abamectin (whose acute toxicity rating comes from the United States Environmental Protection Agency, EPA classification), Cypermethrin and Chlorpyrifos are classified as “moderately hazardous” but are extremely highly toxic to bees and hymenopterans and aquatic fauna and can affect negatively a whole array of natural pest enemies (Heong and Schoenly, 1998; IRRI, 2011).

In terms of Lethal Dosage (LD50) values, it can be seen that the 2 most reported pesticides: Methomyl and Abamectin were also the ones with the highest acute toxicity with values of 17 mg/kg and 10 mg/kg, respectively.

Table 1. Percentage of sampled farmers who reported using synthetic insecticides by crop, market and GAP certification

Pesticide name	WHO Toxic Class.[1]	LD_{50}[2]	Percentage of the farmers used the synthetic insecticide													Number of times reported
			A (sold in foreign or domestic markets)								B (sold in domestic markets only)					
			Asparagus		Calamondin		Roseapple		Coconut		Guava	Pak kwan tung	Cucumber	Lettuce	Yard long bean	
			GAP n[3] = 15	Non-GAP n=10	GAP n = 2	Non-GAP n = 4	GAP n = 12	Non-GAP n = 10	GAP n = 2	Non-GAP n = 1	Non-GAP n = 12	Non-GAP n = 9	Non-GAP n = 1	Non-GAP n = 4	Non-GAP n = 4	
Methomyl (lannate 90)	Ib	17	60	50	50	75	83	60	50		75	44		100	50	50
Abamectin	Not listed	10	60	50	100	100	58	40	50		33	44	100	50	25	44
Cypermethrin	II	250	33	40		25	25	40			25	22			100	23
Chlorpyrifos	II	135					8.3	10		100	75	22				14
Omethoate	Ib	50					8.3	20			8.3		100	25		6
Carbosulfan	II	250					25				8.3		100			5
Chlorantraniliprole (prevathon)	U	>5000	6.7						50			11				3
Malathion	III	2100	6.7						50		8.3					3
Dimethoate	II	150					8.3	10			8.3					3
Fipronil	II	92										33				3
Profenofos	II	358										33				3
Dicofol	II	690					8.3					11				2
Dicrotophos	Ib	22										11		25		2
Indoxacarb	II	268		10											100	2
Dichlorvos	Ib	56									17					2

Table continues in the next page.

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Pesticide name	WHO Toxic Class.[1]	LD_{50}[2]	A (sold in foreign or domestic markets): Asparagus GAP $n^3 = 15$	Asparagus Non-GAP n=10	Calamondin GAP n = 2	Calamondin Non-GAP n = 4	Roseapple GAP n = 12	Roseapple Non-GAP n = 10	Coconut GAP n = 2	Coconut Non-GAP n = 1	B (sold in domestic markets only): Guava Non-GAP n = 12	Pak kwan tung Non-GAP n = 9	Cucumber Non-GAP n = 1	Lettuce Non-GAP n = 4	Yard long bean Non-GAP n = 4	Number of times reported
Emamectin benzoate	Not listed	92.6	6.7									11				2
Ethion	II	208					17									2
Fenobucarb (BMPC)	II	620					8.3	10								2
Quinalphos	II	62					8.3	10								2
Metrifonate or trichlorfon	II	250					8.3									1

[1]The World Health Organization classification of pesticides by hazard: Ib = Highly hazardous; II = Moderately hazardous; U = Unlikely to present acute hazard in normal use.
III = slightly hazardous.
[2] The LD_{50} value is a statistical estimate of the number of mg of toxicant per kg of bodyweight required to kill 50% of a large population of test animals. All values from WHO (2010) except for Abamectin and Emamectin benzoate which are from Tomlin (2006).
[3] Number of farmers interviewed.

Table 2. Percentage of sampled farmers who reported using synthetic fungicides by crop, market and GAP certification.

Pesticide name	WHO Toxic Class.[1]	LD_{50}[2]	Percentage of the farmers used the synthetic fungicide											Number of times reported
			A (sold in foreign or domestic markets)						B (sold in domestic markets only)					
			Asparagus		Calamondin		Roseapple		Guava	Pak kwan tung	Cucumber	Lettuce	Yard long pea	
			n[3] = 15	n=10	n = 2	n = 4	n = 12	n = 10	n = 12	n = 9	n = 1	n = 4	n = 4	
			GAP	Non-GAP	GAP	Non-GAP	GAP	Non-GAP	Non-GAP	Non-GAP	Non-GAP	Non-GAP	Non-GAP	
Carbendazim	U	>10000	73	50	50		66	40	58	22	100	50		41
Mancozeb	U	>8000	47	33			8.3							11
Copper compound[4]	II		27	20	50	25		10					25	10
Metalaxyl	II	670	6.7				8.3			33		25		6
Propineb (Antracol)	U	8500	6.7						16	11			25	5
Chlorothalonil	U	>10000	6.7		50		8.3							3
Propiconazole +prochloraz	II	1520 /1600	6.7	10							100			3
Benomyl	U	>10000					8.3							1
Difenoconazole	II	1453	6.7											1
Propiconazole	II	1520					8.3							1

[1] The World Health Organization classification of pesticides by hazard: II =Moderately hazardous and U = Unlikely to present acute hazard in normal use.

[2] The LD_{50} value is a statistical estimate of the number of mg of toxicant per kg of bodyweight required to kill 50% of a large population of test animals. All values from WHO (2010)

[3] Number of farmers interviewed.

[4] Either copper hydroxide (LD_{50} = 1000 mg/kg), copper oxychloride (LD_{50} = 1440 mg/kg) or copper sulfate (LD_{50} = 300 mg/kg).

Similarly to the case of insecticides, Table 2 shows that the most frequently reported synthetic fungicides used by at least 10% of the farmers sampled were: Carbendazim, Mancozeb, a Copper compound, and Metalaxyl. These fungicides are less hazardous than the reported insecticides shown in Table 1. Copper compounds (copper hydroxide, copper oxychloride or copper sulfate) and Metalaxyl are classified as "moderately hazardous" by the WHO, and Carbendazim and Mancozeb are classified as "unlikely to present acute hazard in normal use".

Farmers were asked about the availability of information related to agricultural inputs (i.e. amounts of pesticide, fertilizers, fuel for spraying, etc.) used for producing their crops. The large majority (over 97%) of the farmers sampled answered that they did not practice daily data recording. This is noteworthy, especially in the case of the GAP farmers, since one of the standard's requirements expressly states the importance of data recording and traceability (NBACFS, 2009).

Later 56 GAP farmers were asked if they perceived a change in the amount of pesticide they spray on their crops, compared to the time when they had not yet started to implement the GAP standard. Those who responded that they did not know, did not remember or were cultivating a different crop before obtaining the GAP license, were excluded from the results. In the end, 19 workable answers were obtained. Of them, 15 farmers (79%) explained that their way of spraying pesticide did not change since they had obtained the GAP license; three farmers (16%) replied that since implementing the GAP program they had to report to the company who bought their produce if pesticides had been sprayed during or near the crop harvest period to avoid it reaching markets with high residue levels; and one farmer (5%) replied that the difference was that GAP farmers tried to use less pesticides in comparison to non-GAP farmers.

Next, practices regarding pesticide application between 50 GAP and 80 non-GAP farmers were compared. The questions asked were based on the information provided by the guidance of the GAP Standard (Section A.3, Appendix A of TAS 9001-2009,) and conformed in a similar way as the one used by Schreinemachers *et al.* (2012b) with farmers in Chiang Mai province.

Table 3 shows the results. It is seen that all of the farmers used synthetic pesticides and that a considerable proportion of farmers complemented the use of synthetic pesticides with locally produced herb or medicinal plant based pesticides, 72% for GAP farmers and 83.75% for non-GAP, with no statistically significant difference. When asked for the reason of using such non-synthetic pesticides, many farmers expressed that it was mainly by economic reasons, since they could produce it cheaply at home or buy them at lower prices compared to those of synthetic pesticides.

Table 3. Pest control and pesticide handling by GAP farmers compared to non-GAP farmers.

Questions	GAP (total number :50)		Non-GAP (total number : 80)		t-test[2]	
	No.[1]	Percent	No.	Percent	t value	significance
Method of pest control:						
Use of synthetic pesticide	50	100	80	100	-	-
Use Only synthetic?	36	72	67	83.75	1.54	ns[3]
Pesticide handling						
Use of Pesticide in preventive way?	46	92	75	93.75	0.37	ns
Follow label instructions?	42	84	67	83.75	0.04	ns
Applies by own initiative	46	92	65	81.25	1.83	ns
Do you mix insecticide and fungicide	44	88	69	86.25	0.29	ns
Mix pesticides (ins-ins or fungi-fungi)?	50	100	77	96.25	1.75	ns
Take in account temperatures and wind	50	100	78	97.50	1.42	ns
Protection						
(a) hat	45	90	65	81.25	1.42	ns
(b) mask	10	20	21	26.25	0.83	ns
(c) aymong	45	90	73	91.25	0.23	ns
(d) long sleeve shirt	46	92	78	97.50	1.65	ns
(e) long pants	46	92	74	92.50	0.92	ns
(f) boots	1	2	1	1.25	0.32	ns
(g) gloves	2	4	4	5	0.27	ns
(h) glasses	0	0	1	1.25	1.00	ns
(i) Ninja Shoes	1	2	3	3.75	0.60	ns
(j) Shower after spraying/wash clothes	50	100	80	100	-	-
Training						
Received training in past 2 years.						
(a) less than 3 hr	7	14	5	6	1.20	ns
(b) 3 hrs	5	10	6	8	0.48	ns
(c) 1 day	3	6	1	1	1.31	ns
(d) cannot remember	5	10	5	6	0.78	ns
(e) not trained	30	60	63	79	1.30	ns

[1] No. is the number of farmers who answered affirmatively to the question.
[2] Two tailed two samples mean comparison test with unequal variances.
[3] ns; not significant at the 0.05 level.

In terms of pesticide handling, no statistically significant differences between the two farmer groups were found, although two noteworthy aspects were note. First, the majority of farmers (92% of GAP farmers and 93.75% of non-GAP farmers) informed that they sprayed pesticides in a preventive way at regular intervals irrespective of the presence and abundance of pest populations. Secondly, they said that they determined pesticide dosage and frequency of pesticide use according to the product labels and also according to their own initiative when signs of an imminent pest attack were observed.

Most of the farmers explained that they normally mixed two or more pesticides together before spraying. This was found for both insecticides and fungicides. In all cases, the farmers commented that this practice increased the effectiveness in killing pests.

When asked about the climate factors, most responded that they took them into account when spraying, and almost all respondents (GAP and non-GAP farmers) said temperature or radiation and wind were the most relevant.

In terms of worker safety by wearing adequate clothing and gear, it was found that most of the farmers reported covering their mouths, arms and legs when spraying pesticides, although very few reported covering their feet or their eyes. Almost all said they washed themselves after spraying. No statistically differences were found between the means of both groups.

Finally, when asked about training, it was found that 60% of GAP farmers reported not receiving any. In the case of non-GAP farmers it was 79%, although no significant differences were found between their means. Those who received training explained that it lasted for a period shorter than one day. Both groups of farmers reported that the training events were provided by the DoAE.

3.4 Discussion

The study related to this chapter showed that the horticultural crops from Damnoen Saduak which were exported to different countries were being produced both by GAP and non-GAP farmers. In contrast, crops that were being sold in domestic markets were produced exclusively by farmers who were not GAP certified. This points out that obtaining a license is an important requirement (if not the most) for enabling farmers to participate in international markets. Actually, some of the trading companies who deal with the produce from this area request farmers to have the GAP certificate, according to the interviews with farmers.

In this sense, the GAP program seems to be successful as in improving conditions for individual and groups of farmers from a socio-economic standpoint. Amekawa (2013) has highlighted the practical usefulness of the GAP program describing it as counterforce to major private Good Agricultural Practices approaches such as GlobalGAP, that although they contribute to improving worker safety, pesticide use, and environmental protection, they tend to cater to the interests of well-resourced large-scale producers.

From the food security standpoint though, the results showed that the implementation of the standard is still incipient. It was observed that most of the farmers chose to use the same types of synthetic pesticides. No evidence that suggested that GAP farmers opted to use less hazardous pesticides compared to non-GAP farmers was found despite the standard incorporates the principles of alternative pest management strategies such as those of Integrated Pest Management. Instead it was observed that the most frequently reported synthetic pesticide used by both groups of farmers was Methomyl and Abamectin, which were also the most hazardous.

The majority of farmers from both groups reported that they regularly used non-synthetic pesticides, alternating its use with the synthetic ones, although the main reason seemed unrelated to environmental or health concerns but with reducing costs.

One significant finding that exposed a deficiency in the implementation of the GAP standard was that none of the initial fifty GAP farmers surveyed were keeping records of their pest management activities, therefore preventing audits from being done by the DoA. This situation makes it unfeasible to evaluate how well the agricultural practices are being done in respect to the standard compliance.

The DoA itself has recognized that its efforts in controlling farmers practices are put mainly in the final stage of crop production, through the testing of pesticide residues of fruits and vegetables before they are available to consumers (Sardsud, 2007; Wannamolee, 2008; Schreinemachers *et al.*, 2012b; Amekawa, 2013).

Overlooking the monitoring of on-farm stages of food production can expose workers and the environment to preventable risks that are caused by pesticides. For instance, the practice of preventive spraying reported by the GAP farmers (and non-GAP farmers alike) may denote a misuse or overuse of pesticides which cannot be assessed or even identified by monitoring efforts such as residue testing. This stresses the importance of data recording so that it can be used in audits necessary to orient farmers to successfully implement the GAP program.

In terms of pesticide handling and worker protection GAP farmers were not performing better than non-GAP farmers. This suggests that certified farmers working conditions have not become safer since they started carrying out the program and may be facing the same health and safety risks as the rest of farmers in the area.

The underlying factor by which the compliance with the GAP requirements proved to be a difficult task for the farmers may be due to a deficient or lack of training from the DoAE. This in turn may be attributable to insufficient governmental resources. An officer responsible for the GAP program from the DoAE explained that in 2013, there were only nine of such officers working in Damnoen Saduak District and that each had to deal with hundreds of farmers that had applied for the GAP certification. He explained that their job consisted of helping them prepare for the initial inspection required to obtain the GAP license by training them about how to implement the eight farm related elements of the GAP standard. As a result it seems that the DoAE's GAP training component is inadequate and cannot ensure that farmers will be able to improve their current pesticide use practices towards better food security, worker safety and amelioration of environmental degradation, the main principles of the GAP standard.

The results indicate that the GAP program has so far focused on the broad certification of farmers so that they are not excluded from participating in markets which otherwise would not be available to them. But to do this, the criteria for granting the GAP license had to be set loose. A similar situation was found by Amekawa (2013) when comparing two pummelo production sites in Chaiyaphum province, in which he concluded that actually setting a looser certification criteria was the very strength of the public GAP approach compared to the private ones.

The broad inclusion of farmers into the program can be seen as the first step towards the GAP standard implementation. The next challenges to be met by the MoAC should be to focus on control along the on-farm stages of crop production (audits) and effectively training farmers in IPM methods or other viable pest management alternatives in order to reduce the amount of synthetic pesticide use and reach the other goals of GAP program.

Chapter 4
The GAP effect on pesticide use in asparagus farmers in Damnoen Saduak

4.1 Introduction

Thailand is an agricultural country and one of the biggest world's food exporters (Konuma, 2012; Panuwet *et al.*, 2012). Its heavy reliance on synthetic pesticide use for crop protection and for sustaining high yields (Praneetvatakul *et al.*) in the face of gradually increasing international safety and environmental requirements has led its Ministry of Agriculture to implement the GAP standard (Sardsud, 2007) which promotes safe production of quality fruits and vegetables. At present it mainly aims on avoiding environmental and health risks caused by the excessive use of synthetic pesticides, through a reduction of its demand (Poapongsakorn *et al.*, 1999; Praneetvatakul and Waibel, 2007). Despite this, Thailand is still experiencing a surge in synthetic pesticide use which has led to increasing agricultural production of high value crops such as asparagus (Kunstadter, 2007; Praneetvatakul *et al.*, 2011).

Asparagus is grown mainly by small scale farmers and is characterized by being produced under intensive cropping methods, which rely on high use of synthetic pesticides and other agricultural inputs. Moreover, asparagus is one of the crops with the largest number of certified GAP farms (DOA, 2014).

Many of the shortcomings of the GAP program in Thailand identified in previous studies (Sardsud, 2007; Schreinemachers *et al.*, 2012b; Schreinemachers *et al.*, 2012a; Montano *et al.*, 2015) suggest that the level of implementation of this program is still incipient and therefore, it cannot be easily distinguished from conventional agricultural systems. The major limitations to the effective implementation of the program are: insufficient training, inadequate governmental audits and testing of residues on produce and lack of popularity among farmers on record keeping.

The qualitative comparison of pesticide use in regard to farmer affiliation to the GAP program shown in the previous chapter suggests that the amount and level of hazardousness of pesticides used by GAP certified farmers did not differ from those who did not follow this program (i.e. non-GAP farmers).

The aim of this chapter was to quantitatively evaluate pesticide use differences between GAP and non-GAP asparagus cropping systems. Specifically, the objectives of the study were: to compare the toxicity class of pesticides being used; to assess the level of synthetic pesticide use by farmers (measured as expenditure of pesticides, total amount of active ingredients used and the potential environmental impact they cause); to examine the relationship between pesticide use and yield, and to establish if GAP certification provides an economic reward to farmers by evaluating crop yields, revenue and inputs such as labor, fuel and fertilizer.

4.2 Research Context and Methods

In 2013, Damnoen Saduak Sub District had a total of 55 GAP licensed farmers that produced asparagus (DOA, 2014). From this group 12 farmers were selected and agreed to provide daily records for the upcoming growing season starting from July-August of 2013. This was necessary because they did not normally register information about inputs necessary for the crop production although the GAP standard requires them to do so. Simultaneously, 12 selected non-GAP farmers agreed to do the same.

The data provided consisted of: quantities and expenditures for synthetic insecticides, fungicides, fertilizers, labor and the amount of fuel used for spraying and watering during the harvest period. The names and concentrations of the active ingredients (a.i) used was also recorded by checking the labels of the pesticide containers. Based on the active ingredients the formulations were grouped according to their acute toxicity to mammals according to the World Health Organization (WHO, 2010).

To assess differences in pesticide intensity use in terms of potential environmental impact a rating system developed by Kovach *et al.* (1992) known as the Environmental Impact Quotient (EIQ) was used. The system integrates data of pesticide effects on farm workers, consumers and ecological components to determine the hazard potential of a pesticide.

In order to determine a field use rating the EIQ base value was multiplied by the dosage and concentration of the active ingredients of the formulated products used by each farmer as follows:

$$\text{EIQ Field Use Rating } = \sum_{P=1}^{n} EIQ \times D \times C$$

in which EIQ is the EIQ base value of a pesticide p for a total of n pesticides, D is the dosage or application rate (kg/rai) of the pesticide and C is concentration or percentage measured as % of active ingredient.

The average EIQ field use ratings were used to compare the different pest management programs (GAP and non-GAP) and determine which one was more likely to have the lower environmental impact.

To examine plot yield and compare economic data between GAP and non-GAP farms the sale receipts each farmer received after selling their produce were borrowed. In cases when farmers did not keep the receipts, output information was obtained from the books kept by local asparagus grower groups. The data consisted of total asparagus yield, price per quality class and total revenue. Yield was recorded in kilograms (kg.), plot areas were recorded in “rai”, a unit equal to

1.600 square meters (40 by 40 meters) and the currency used was the Thailand baht (THB).

Two tailed two samples mean comparison tests with unequal variances were used to detect significant differences between pesticide use intensity variables. This procedure was also used for comparing variables related to the outputs and inputs of asparagus production. A Pearson's correlation coefficient test was applied for comparing the relationship between pesticide use intensity variables and crop yields.

4.3 Results.

Table 4 presents data in terms of the toxicity classification of the synthetic pesticide formulations used by farmers according to their affiliation to the GAP program. It shows that no pesticide categorized as “Extremely hazardous” by the World Health Organization was used, although 16.7% of the GAP farmers and 33.3% of non-GAP farmers used pesticides under the class “Highly hazardous”. The percentage of use of less hazardous pesticides was high for both GAP and non-GAP farmers, especially those classified as “Unlikely to present acute hazard in normal use”. The pesticides under the last category, although classified as the least toxic to humans, were also responsible of producing the highest potential environmental impact as shown by their EIQ field use rating.

Table 5 shows that during the growing season of the asparagus crops examined (1.7 months for GAP farmers and 1.8 months, for non-GAP farmers) the levels of pesticide intensity, measured as the average of pesticide expenditure, amount of active ingredients used per month and the environmental impact quotient (EIQ) field use rating, did not show significant differences between GAP and non-GAP farmers, although there was a tendency for GAP farmers to show smaller values in pesticide expenditure and EIQ field use rate.

Table 4. Synthetic pesticides used by toxicity classification and the potential environmental impact produced.

Toxicity Hazard Categories[1]	Number of pesticide formulations used		% of farmers using them		Average EIQ field use rating/rai	
	GAP	Non-GAP	GAP	Non-GAP	GAP	Non-GAP
Ib Highly hazardous	1	2	16.7	33.3	13.7	37.2
II Moderately hazardous	5	6	41.7	50.0	66.9	39.5
III Slightly hazardous	2	1	25.0	16.7	2.6	2.0
U Unlikely to present acute hazard in normal use	7	4	66.7	100.0	215.4	262.2
Unclassified	1	3	41.7	58.3	0.8	1.4
Total	16	16			299.4	342.2

[1] From the World Health Organization (WHO, 2010).

Table 5. Level of pesticide used per farmer and the potential environmental impact produced.

	Mean ± standard error		
	Pesticide expenditure (THB /rai/ month)	Active ingredients (kg/rai/month)	Average EIQ field use rating /rai/month
GAP	156.7±32.4	0.5±0.1	14.7±2.6
Non-GAP	192.8±31.7	0.5±0.1	15.7±2.4
p value[1]	0.435	0.855	0.772

[1] A two tailed two samples mean comparison test with unequal variances

Fig. 8 shows diagrams that plot yield in Thai baht (THB) of asparagus per rai of cultivated land against the average EIQ field use rating (diagrams A and B) and total pesticide expenditure in THB per rai (diagrams C and D). Each dot represents the data for one harvest cycle studied. The correlations are statistically significant at the 5% level with the exception of Diagram A which shows a near-significant trend (p= 0.06).

All diagrams suggest a positive relationship between asparagus crops yield and pesticide use in terms of potential environmental impact and monetary value. In the case of plots under the GAP program, a 1,000 THB per rai increase of yield was associated with a 0.8 unit increase of EIQ field use rate and 7.3 THB per rai of pesticide expenditure. In the case of non-GAP plots, the increased values observed were 1.0 unit per rai and 15 THB per rai, respectively.

Fig. 8 does not include diagrams showing the relationship between yield and total amount of active ingredients used in kg per rai since no significant correlation was found between these two variables in neither group studied.

Table 6 shows values of the asparagus yields and inputs for the growing season studied. In terms of outputs it shows that non-GAP farmers obtained a higher yield and crop revenue, although a t-test did not show statistically significant differences between their means. In terms of inputs, the non-GAP farmers' pesticide use was higher, while fertilizer expenditure, hired labor and the amount of fuel (for watering and spraying pesticides) was lower compared to the GAP farmers, although as in the case of yields, no statistical significant differences in their means were found .

Table 6. Outputs and inputs used during growing season of asparagus crops by pest management system.

	Yield (kg/rai)	Crop revenue (THB/rai)	Pesticide use (THB /rai)	Fertilizer expenditure (THB /rai)	Hired labor (THB /rai)	Fuel (THB /rai)
GAP	255.0±55.5	14513.1±3208	256.4±48.9	895.4±198.1	3442±931.1	227.6±52.1
Non-GAP	303.0±73.7	19877.5±4706.7	365±79.3	522.2±105.9	3180.2±918.2	160.4±18.5
p-value[1]	0.609	0.358	0.259	0.115	0.843	0.244

[1] A two tailed two samples mean comparison test with unequal variances.

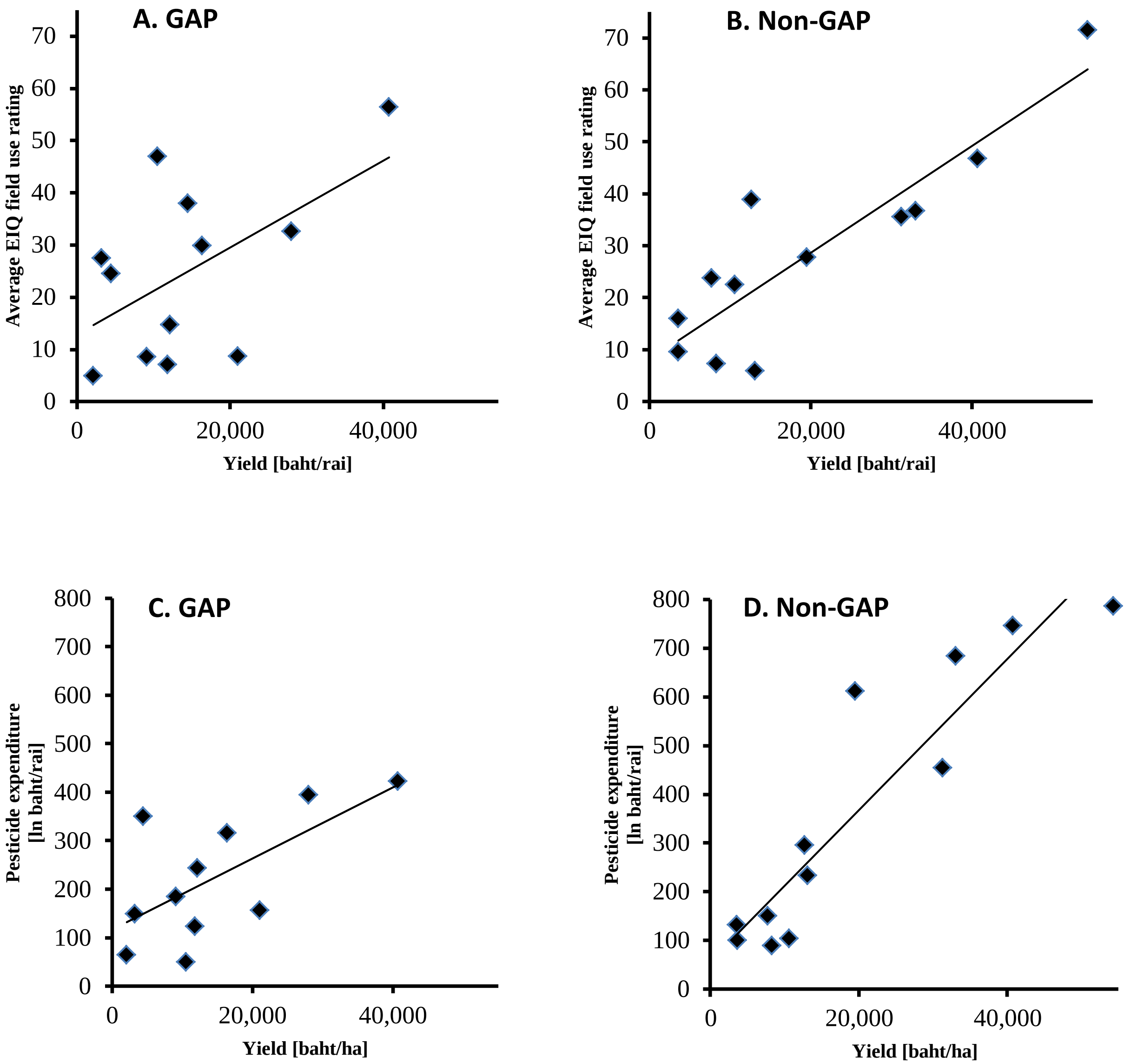

Fig. 8. Correlation between yield and pesticide use intensity.
Notes: Each dot represents one observed crop during harvest season.
Regression A: Coeff.= 0.0008 (p = 0.0628), n =12, R^2 =0.304, F = 4.381
Regression B: Coeff.= 0.0010 (p = 0.0001), n = 12, R^2 = 0.78, F = 35.91
Regression C: Coeff.= 0.0073 (p = 0.0297), n = 11, R^2 = 0.425, F = 6.65
Regression D: Coeff.= 0.0155 (p = 0.00002), n = 12, R^2 = 0.84, F = 55.31

4.4 Discussion.

The results of this chapter showed no significant difference between the GAP and non-GAP cropping management in terms of pesticide use. The asparagus farmers under the GAP program seem to rely on synthetics pesticides for crop protection as heavily as those who are not implementing this standard.

These results are in line with the findings of Schreinemachers *et al.* (2011) and Schreinemachers *et al.* (2012b), which could not identify clear differences in pesticide use intensity by comparing GAP and non-GAP horticultural farmers in the northern highlands of Thailand, either.

The literatures support the notion that overuse of synthetic pesticides is common in Thailand given that the country is positioning itself as a major agricultural exporter, that its government provides tax exemption to pesticide imports and that it occasionally provides pesticides for free to farmers when pest outbreaks occur (Poramacom, 2001; Panuwet *et al.*, 2012). Other factors include farmers' lack of knowledge about alternative pest control methods such as Integrated Pest Management (IPM) and that Thai policy has not given priority to them (Grovermann *et al.*, 2013).

IPM program management suggests that control methods such as monitoring and identification of pests lead to appropriate decisions, of which pesticides should be used in order to reduce the exposure to hazardous chemicals. Although the GAP standard accepts the principles of IPM, I found that in practice farmers certified with a GAP license utilized pesticides with formulations of toxicity levels comparable to non-GAP farmers, which included some classified as highly hazardous and moderately hazardous under the "WHO Recommended Classification by Hazard". This is an indication that crop protection methods did not differ substantially between GAP and non-GAP farmers.

Another indication is that the intensity of pesticide as measured by pesticide expenditure, total amount of active ingredients utilized and the potential environmental impact caused was also similar between the groups. These results suggest that at present the GAP program is not effectively promoting appropriate management that may lead to a significant reduction in synthetic pesticide use.

From the monetary point of view it was observed that GAP farmers did not experience a more advantageous situation by the fact of being certified, a result in line with data reported for GAP farmers in Asia (Sardsud, 2007). I found that yields and crop revenues obtained were similar between both groups. As for inputs, the expenditures for pesticides, labor and fuel were was also comparable, although fertilizer expenditure was slightly higher for GAP farmers.

Even if there may not be a direct or short term economic reward for farmers under the GAP program there still may be benefit of being certified. By holding a GAP license farmers are enabled to establish contracts with buying companies (through grower groups) that require them to be certified by the program, and therefore can expand their options of markets where to enter. This aspect of the GAP program has led to the inclusion of a large number of smallholders into markets that otherwise would not have been possible to access (Wannamolee, 2008; Amekawa, 2013).

Finally, it was found that both GAP and non-GAP farmers showed a positive relationship between pesticide use and yield. Specifically, yield was both correlated to pesticide expenditure and to potential environmental impact. If policies to enable the promotion and development of non-synthetic methods for crop protection are not given the priority needed to be adequately implemented in Thailand (Kunstadter, 2007), it seems that at present, farmers will continue to face challenges in trying to reduce synthetic pesticide use while at the same time, trying to satisfy the increasing demand of vegetables and fruits from both domestic and foreign markets (Panuwet *et al.*, 2012).

The development of the national GAP program by the Ministry of Agriculture and Cooperatives has allowed small scale farmers to access external markets and face increasingly stringent food safety and quality requirements. The implementation of the program by the government has focused primarily on controlling pesticide residues on produce to avoid chemical contamination (Sardsud, 2007), but the results point out inspection and auditing capacities still need improvement to fully implement the standard (Montano *et al.*, unpublished). Special attention should be paid on the monitoring and control of pesticide use intensity at farm level.

Chapter 5
Information, concerns about pesticide effects and the GAP program

5.1 Introduction

Synthetic pesticides play a major role in pest management in Thailand's agriculture as its use is currently increasing in order to protect crops and improve yields (Poramacom, 2001; Panuwet *et al.*, 2012). However, recently a consensus has emerged that a range of highly toxic pesticides are being used beyond economically optimal rates by Thai farmers (Ruhs *et al.*, 1999)

To achieve a reduction and proper usage of synthetic pesticides, the GAP program has established as one of its duties to orient farmers to adopt alternative production methods, such as Integrated Pest Management (IPM), whose principles are accepted by the GAP standard. (NBACFS, 2009; Schreinemachers *et al.*, 2012b).

By doing so, the GAP program may have influenced the concern farmers have about the negative effects of synthetic pesticides. Therefore, farmers who are certified with a GAP license may show a higher awareness of the risks linked with pesticide use, compared to those who are not implementing the GAP standard. In addition, and more importantly, it may influence how GAP farmers make decisions about pest management, orienting them to adopt alternative methods.

This chapter examines the effect the GAP program has had on the level of concern asparagus farmers' had regarding the negative effects of synthetic pesticide use on human health and the environment in Damnoen Saduak District. It also assessed the importance farmers (whether they are participating in the GAP program or not) gave to the Department of Agricultural Extension (DoAE) as a source of information for pest management decisions in relation to other information sources. The DoAE is responsible for providing GAP training and advisory services for the farmers who apply for a license. As its name implies, the DoAE is also responsible for providing extension services to farmers who are not participating in the GAP program (Sardsud, 2007). By understanding farmers' awareness and attitudes towards information I expected to find useful insights for policy making that may help improve the adoption of alternative pest management practices.

5.2 Research Context and Methods

This study relevant to this chapter was conducted in Tha Nat and Damnoen Saduak, Sub Districts of the Damnoen Saduak District, during the period from April to May, 2013. A survey was conducted to 86 randomly selected asparagus farmers, of which 38 were certified with a GAP license (hence referred as GAP farmers) and 40 that were not part of the program (hence referred as non-GAP farmers).

Certification involves a process where official inspectors from the DoA visit farmers' fields to observe its conditions and interview them using a prescribed checklist on eight production aspects: Water sources, farm conditions, agrochemical use, product storage and shipping, record keeping, product safety, farm management, and harvest and post-harvest practices. Inspectors should take samples of growing crops and soils in order to test them for pesticide residues. To maintain their certification status, farmers must undergo audits throughout a year and to be recertified they must restart the entire process.

In order to compare differences between GAP and non-GAP farmers, structured interviews were conducted in Thai language with the assistance of a native speaker who translated the data into English. First basic socioeconomic data such as farmer's age, experience, size of his/her household, land area (measured in rai, where one rai is equivalent to 0.16 ha or 40 by 40 meters) and annual income was obtained. Second, farmers were asked how concerned they were about pollution from pesticide runoff or leaching into the water and soil. Then, they were asked questions how concerned they were about illness and injury caused to human health from: mixing/loading pesticides, applying pesticides, residues on food and pesticide residues in the drinking water. Farmers were also asked about their concern of injury, disease or death to birds, fish, or wildlife from pesticide exposure.

The level of concern was measured in a similar fashion as done by Lichtenberg and Zimmerman (1999), in terms of “seriousness” along a five part-scale ranging from 1 indicating “not at all serious” to 5 indicating “very serious”.

The third part of the survey consisted of asking questions about the perceived importance they gave to information sources for taking pest management decisions. The sources were selected according to previous communications held with farmers who did not belong to the surveyed sample and from advice of some officers from the DoAE. These are: Direct field observations, other farmers, pesticide labels, pesticide dealers, news and media, the DoAE and local Cooperatives. As in the case of assessing concerns, a scale of 1 to 5 was used. In order to minimize bias, the last question asked to farmers was if they were certified by the GAP program or not.

Socioeconomic comparisons between GAP and non-GAP farmers were done by running two sample t-test assuming unequal variances. To understand the interaction between being GAP verification and the questions about negative pesticide effects on the level of concern of farmers, a two way Analysis of variance (ANOVA) was performed. The same test was used to understand the interaction of GAP certification and of sources of information on the perceived importance farmers assign to them. When significant differences were found among means a multiple comparisons Tukey's test was performed to identify which means differed significantly from each other.

5.3 Results.

Table 7 shows that the socioeconomic condition of the surveyed asparagus farmers was similar between GAP and non-GAP groups. No statistically significant differences were found on age, education, experience, land area, gender or reported annual income, although a significant difference was found for household size. The non-GAP farmers had in average about one more member per household. In general, both groups of farmers can be described as being comprised of smallholders, mostly male (over 80%), live in households of 3 or 4 people, completed at least primary school education and have more than 10 years of experience in cultivating crops. As for annual income, the average amount reported showed the greatest variability.

The score for concern that farmers reported towards pesticide leaching, illness or injury towards human health and wildlife was in the range of 3.60 and 3.95 and can be considered as “serious” (Table 8). The score level did not differ significantly among these issues but significant differences were found across GAP and non-GAP farmer groups ($F(1, 504) = 3.89$, $MSE = 3.949$, $p = 0.049$). GAP farmers conveyed a higher level of concern for all six questions compared to non-GAP farmers. The interaction effect between the type of issues asked about and the implementation of the GAP program over the farmers’ levels of concern was not significant.

Table 7. Socioeconomic data of surveyed asparagus farmers using t-test for equality of means.

Farmers general information	GAP	Non-GAP	t-test[1]	
			t value	significance
Age	46.92±11.53	45.27±11.48	0.66	ns
Education (years of schooling)	6.84±2.60	8.02±3.12	1.87	ns
Experience (years)	24.63±10.63	21.02±11.35	1.50	ns
Household size (members)	3.87±1.36	4.69±1.40	2.73	Significant (P=0.008)
Land area (rai)	7.26±6.34	7.53±4.96	0.22	ns
Gender (% female)	0.18±0.39	0.17±0.34	0.21	ns
Reported average annual income (THB)	391,342±255,380	340,208±298,822	0.40	ns

[1] Two tailed two samples mean comparison test with unequal variances.
[2] ns not significant at the 0.05 level.

Table 8. Concern of farmers over general environmental and synthetic pesticide issues and, GAP certification.

Level of concern[1]	GAP	Non-GAP
Pollution from pesticide/chemical runoff or leaching	3.63±0.67[2]	3.60±0.98
Illness or injury arising from pesticide exposure scenarios:		
from mixing/loading pesticides	3.89±0.86	3.73±1.05
from applying pesticides	3.95±1.04	3.75±0.96
from residues on food	3.89±1.13	3.56±1.09
from pesticides in drinking water	3.84±1.08	3.77±1.08
Injury, disease or death to birds, fish, or wildlife from pesticide exposure.	3.76±0.97	3.50±1.05
Average	3.83	3.65

[1]Attitudes are listed in the order in which they appeared on the questionnaire. Seriousness was evaluated by scores from 1 to 5, in which 1 is not serious and 5 means most serious.
[2] Standard error.

The scores for the importance farmers gave to sources of information (Table 9) differed significantly among them ($F (6, 588) = 153.92$, $MSE = 110.86$, $p < 0.000$). A post hoc multiple comparison test (Tukey HSD) showed that the scores of each source differed from one another at the 0.05 level of significance, except for the following pairs: Pesticide dealers and Pesticide labels ($p = 0.23$) and; Department of Agriculture and Cooperatives ($p = 0.07$). As no significant interaction was found between the type of source of information asked about and the implementation of the GAP program over the importance given to such sources, relative importance of information sources were not different between GAP and non-GAP farmers.

Table 9. Perceived importance of information sources and the GAP certification.

Information sources for pest management decisions[1]	GAP	Non-GAP	Average
Direct field observations	3.82±0.865[2]	4.00±0.945	3.91
Other growers (farmers)	3.42±0.722	3.48±0.899	3.45
Pesticide labels	2.79±0.811	3.15±1.13	2.97
Pesticide dealer (store)	2.66±0.847	2.83±1.10	2.75
News and media	1.53±0.893	1.63±0.866	1.58
Department of Agricultural Extension	1.13±0.578	1.21±0.824	1.17
Local Cooperatives	1.11±0.509	1.10±0.472	1.11

[1] Sources are listed in order of importance given by the farmers.
[2] Standard error.

Based on these results the information sources were grouped and listed according to how important they are to farmers. In descending order: 1. Direct field observations, considered as very important; 2. Other growers, considered important; 3. Pesticide labels and pesticide dealers, considered as somewhat important; 4. News and media, considered as not so important and, 5. Department of Agriculture and farmers Cooperatives, considered as not important at all.

The GAP program seemed to affect farmers' appraisal of sources of information. Differences on how important GAP and non-GAP farmers considered these sources were on the limit of significance (P= 0.052). Non-GAP farmers considered them slightly more important than GAP farmers. The only exception was for Cooperatives which obtained almost identical scores (1.11 for GAP farmers and 1.10 for non-GAP farmers).

5.4 Discussion

The socioeconomic data from this study suggests that all asparagus farmers surveyed came from the same socioeconomic background. This allowed us to attribute any differences about their concerns and perceptions to the conditions of whether the farmer was participating in the GAP program or not. Although one socioeconomic factor was found to differ significantly between groups: size of the household (Mean for GAP farmers: 3.87 vs. Mean non-GAP farmers: 4.69). The reason for this is not clear since the other variables measured: age, education, experience, area being cultivated, gender and reported av. annual income did not differ significantly.

Asparagus farmers' concern towards negative pesticide effects was described as "serious". This level of concern was reported in the same way whether activities involving pesticides affected human health directly (during mixing, loading and applying pesticides), indirectly (through pesticide runoff or leaching or because of the presence of residues on food and water) or harmed the environment (through injury, disease or death to fish, birds and wildlife).

The low variance among answers and the relatively high level of concern expressed can be seen as a sign that farmers, whether they were participating in the GAP program or not, were aware that synthetic pesticide presented risks. This may be a consequence of a global trend that has heightened environmental awareness and favors a shift from conventional agriculture to an alternative one characterized mainly by a reduction of synthetic agrochemicals (Beus and Dunlap, 1990; Vandermeer, 1995). Specifically, because of the introduction of several food safety and quality standards in response to regulatory developments, consumer concerns about food safety, and an increasingly competitive environment for high value-agricultural food products (Reardon and Farina, 2001).

At the national level, farmers' awareness may have been further promoted by the "The Philosophy of Sufficiency Economy" policy, bestowed by Thai King in 1997. It was used as an comprehensive guideline for formulating the country's National Development Plans (Chalapati, 2009; Yuenyong and Narjaikaew, 2009; Amekawa, 2013) and has prompted what is known in Thailand as "New Theory Agriculture", whose main purpose is to make farmers more self-reliant through holistic management of their land, while living harmoniously with nature and within society (Piboolsravut, 2004).

The implementation of the GAP program since 2004 seemed to have also contributed to raising the level of concern of farmers about the negative effects of synthetic pesticides, given that those who were implementing the program expressed a slightly higher concern than those who were not.

However, it would be inappropriate to suggest that such awareness reflects the respondents' true state of mind or behavior since the questions used in this survey could provide subtle or overt clues to the purpose of the research (McDonald and Glynn, 1994), and thus, biasing farmers response. Awareness by itself cannot be used as evidence of farmers adopting measures to reduce synthetic pesticides; it can only be seen as the first step of this process (Green and Heffernan, 1987).

Montano *et al.* (unpublished) observed this situation by analyzing quantitative data about synthetic pesticide use (from a subsample of the surveyed asparagus farmers from this study) and finding that there were no significant differences between quantities of pesticides used by GAP and non-GAP farmers.

The high concern expressed by farmers may reflect a desire of each respondent to appear to have more socially acceptable attitudes towards synthetic pesticide use. GAP farmers in particular, who expressed even slightly higher levels of concern, may have done so because they understand the legal and contractual obligations that they have to produce safer food. They realize that they are subject to stricter quality controls from the DoA or private companies which routinely check for pesticide residue limits on produce before they reach the market (Wannamolee, 2008; Schreinemachers *et al.*, 2012b; Amekawa, 2013).

Most noteworthy was the fact that farmers perceived and rated the sources of information importance differently. Both GAP and non-GAP farmers ranked them in order of importance, giving the highest priority to first-hand sources (such as their own experience and that of others farmers) and the least importance to local Cooperatives and the Department of Agricultural Extension (DoAE).

Other studies that have examined the relative popularity of information sources to farmers show that generally, extension agents are regarded as key components for the adoption of new knowledge. For example, a study of corn and soy-bean growers in the Mid-Atlantic region of United States by Lichtenberg and Zimmerman (1999) found that extension services ranked as second in importance after direct field observation and pesticide labels. Other researchers measured other concepts such as credibility, preference or usefulness, but ranked information sources in a similar way: For example, Glynn *et al.* (1995) found that both IPM adopters and non-adopters of fruit and vegetables in New York State, United States, considered extension agents as the most credible source after direct field observation and pesticide labels. Feder and Slade (1985) found that contact farmers from northwest India deemed extension as their primary information source. The results of s survey done by Opara (2008) of farmers in Imo State, Nigeria showed that the majority preferred extension agents over other information sources. On the other hand, findings of low popularity of extension agents among farmers as in the study done by Muhammad and Garforth (1999) from Faisalabad, Pakistan, highlight the risks of having poor technology transfers to potential adopters.

This study shows that the DoAE as an information source appears far behind its expected role. The perception of the farmers surveyed reflect that the DoAE may not be providing adequate technical assistance and advice to non-GAP farmers and GAP farmers alike, being the institution who is responsible for both offering extension services and the knowledge to effectively implement the GAP standard.

The previous survey of horticultural farmers in Damnoen Saduak Sub District (Montano *et al.*, unpublished) showed that the DoAE provided insufficient technical assistance and training for reducing synthetic pesticide use or to provide information about Integrated Pesticide Management, or other types of alternative production methods.

The GAP program has focused mainly on the reduction of pesticide use by promoting and enforcing the monitoring of residues (Schreinemachers *et al.*, 2012b; Amekawa, 2013 and Montano et al., unpublished) but in order to further implement the standard, additional actions are necessary to give the farmers incentives to adopt alternative cropping methods. This means to strengthen their policy on how to provide better technical assistance and training and to improve the perception both GAP and Non-Gap farmers have towards the DoAE.

I acknowledge this is a difficult task given that Thailand's agricultural sector continues to rely heavily on synthetic pesticide use and that the DoA and DoAE have limited human and financial resources (Panuwet *et al.*, 2012; 2014).

However, changing the attitudes and perceptions of farmers would facilitate the transition towards alternative methods of pest control that could lead to a reduction of synthetic pesticide use.

Chapter 6 General Discussion

The findings of this study came from a small sample of horticultural farmers in Damnoen Saduak District, Ratchaburi Province, whose practices were evaluated during a short period of time. Because of this, they cannot be considered representative of how the good agricultural practices (GAP) program is being implemented in Thailand. Nonetheless, they are consistent with the findings of Amekawa (2013) in Chaiyaphum Province, Schreinemachers *et al.* (2012a) in Chiang Mai Province and Pongvinyoo *et al.* (2014) in Chumphon Province who also identified a lack of standard compliance. This gives an indication that the results are valid.

The main achievement of the program has been the certification of farmers through the granting of GAP licenses, which are an essential requirement when establishing contracts with buying companies. This has led to the inclusion of a large number of smallholders into international markets who would otherwise not have gained access, thereby positively affected their livelihoods. However, from the food security standpoint, the results showed that implementation of the GAP standard remains incipient. Contrary to the expectation, it was found that GAP farmers did not opt to use less hazardous nor lower quantities of pesticides compared to non-GAP farmers.

It was also revealed that GAP farmers did not obtain any economic reward from being certified, with no incentive to reduce synthetic pesticide use, since the amount sprayed was positively related to crop yield. In addition, GAP farmers did not perform better than non-GAP farmers in terms of pesticide handling and worker protection. That is, working conditions of certified farmers have not become any safer nor have their practices reduced the potential environmental impact caused by synthetic pesticide use.

Both groups of farmers were shown to be highly aware of the negative effects of synthetic pesticide use, expressing their concern with regards human health and the environment. This can be seen as a sign that farmers are interested in reducing their use of synthetic pesticides, although it may also reflect a desire to appear to have more socially acceptable attitudes. Regardless, farmers were not provided with adequate training or guidance about suitable alternatives to synthetic pesticides. This was reflected in the farmers' perceptions of the Department of Agricultural Extension (DoAE), which was regarded both by GAP and non-GAP farmers as the least important source of information (together with local cooperatives) when making pest management decisions. The lack of adequate GAP training was considered an important reason for the poor implementation of the GAP standard. The most noteworthy finding was that none of the GAP farmers surveyed were keeping records of their pest management activities (i.e. pest surveys or pesticide application logs). Another reason was that the Department of Agriculture (DoA) was found to be mainly concentrating its efforts on controlling pest management activities of GAP farmers by testing for pesticide residues in their produce before they reached the market, overlooking the monitoring of farming practices during the on-farm stages of crop production. As a result, no feedback was provided to help farmers improve compliance, potentially putting them and the environment at risk of pesticide overuse or misuse.

In its present form, the GAP program can be characterized as having extensive producer participation through the existence of compromises in its criteria for food safety. This should be seen as a first step towards implementation of the GAP standard. The next step being to give priority to policies aimed at the promotion and development of institutional changes, so that farmers can adopt non-synthetic methods of crop protection. The DoAE needs to strengthen its capacity for GAP training of farmers, while the DoA needs to improve its monitoring of practices through auditing. Achieving this goal will certainly be a difficult task given that Thailand is still a developing country, with a government that has limited human and financial resources (Panuwet *et al.*, 2012; FAOSTAT, 2014). However, if successfully implemented, the GAP program could move in line with more stringent private standards, making it more competitive.

Acknowledgements

I would like to express my special appreciation and thanks to my advisor Professor Dr. Eiji Nawata (Kyoto University). His support was fundamental from the initial stages of this research right up until the last moments before this document was sent out to print. His abundant technical and critical comments are deeply appreciated but most of all, I am grateful for his unceasing encouragement to pursue my academics goals in face of many challenges. This, I believe is the fundamental role of a good teacher.

I am also in debt with Dr. Supamard Panichsakpatana (Kasesart University) who facilitated my research while in Thailand and Dr. Higuchi Hirokazu (Kyoto University) for giving me important feedback on analyzing the survey information and insights on how to expand and continue improving on my research on this topic. Many thanks to Dr. Akamatsu Miki (Kyoto University) for reviewing and contributing with valuable observations to this document.

I would like to express my gratitude to my friend Ms. Aphiradee Khimpitak who assisted me during the field survey. She helped by translating from Thai, driving us by car or motorcycle, preparing the interviews and most importantly offered me clever solutions to practical problems we encountered while collecting data

Next, I'd like to thank all members of my host family the Jaroensabs (Jaran, Nok, Nut and Dao) for accepting me into their home during my stay in Damnoen Saduak District, Ratchaburi province, Thailand in the most hospitable manner.

I cannot forget the friendly assistance and encouragement received all these years from the students and staff of the Laboratory of Tropical Agriculture, graduate School of Agriculture, Kyoto University.

I deeply appreciate the Ministry of Education, Culture, Sports, Science and Technology (Mombukagakusho, MEXT) for giving me financial support through its scholarship which was provided during my say in Japan.

Finally, I would like to thank my parents and all my relatives who supported me through all my life so I could be able to pursue my academic endeavors.

Summary

To provide better and safer food crops, Thailand introduced a public program for good agricultural practices (GAP). Using qualitative and quantitative data from an intensive horticultural production system in Damnoen Saduak District (Ratchaburi Province), an assessment was performed to determine whether farmers implementing the GAP program did better than those not adhering to the standard in terms of synthetic pesticide use. A comparison of farmers' levels of concern over the negative impact of pesticides on health and the environment, and the importance given to sources of information when making pest management decisions was also examined. The results showed that GAP farmers did not use fewer or less hazardous pesticides nor did they handle them in a safer way compared to non-GAP farmers. Both groups expressed their concern over the negative effects of pesticides, referring to the effects as "serious," and perceived the governmental body responsible for implementing the GAP program to be the least important source of information available. These findings reveal poor implementation of the GAP program, which has mainly given emphasis to expansion by certification of farmers and through control of pesticide use via residue testing of produce. It is therefore necessary that the program also make efforts to provide adequate GAP training and improve its auditing capacity when monitoring agricultural practices if the standard is to be further implemented.

APPENDIX

Thai Agricultural Standard, TAS 9001-2009, Good Agricultural Practices Standard for Food Crop. Requirements for Pesticide application.

1. Apply pesticides in accordance with recommendation of Department of Agriculture or recommendation on the label legally registered with Department of Agriculture, Ministry of Agriculture and Cooperatives. The application shall be in line with the found pests, and record the data with complete important essence as shown in the record form in Appendix B (Example of the Data Record Form for Plant Pest Survey and the Application of Pesticide).
2. Shall apply pesticides that have been legally registered with hazardous substance registered No. and recommendation on the label for the use on such crops. Do not use pesticides that are banned to produce, import, export, or have in possession according to Hazardous Substances Act B.E. 2535 (1992) and the revised Act, including those in the indicated prohibited pesticide list of the country trade partners or their provisions. Domestically prohibited substances shall not be used, and stop applying pesticides before harvest in complying with the lap period as indicated on the label accompanying along each pesticide or comply with the official recommendation.
3. Recommendation on the pesticide label shall be read to understand its property and application method prior application.
4. User or controller of pesticide application shall know: plant pests, how to select pesticides and their application rate, chemical sprayers and equipment, nozzles including correct spraying method. Chemical sprayers

shall be checked and serviced that they can be efficiently used at all time. To protect clothes and worker's body from pesticide contamination, the worker is required to wear proper clothes and pesticide protective accessories such as proper mask or nose covering cloth, gloves, hat or cap and boots. To prevent hazard from pesticides, one shall avoid applying a mixture of more than two kinds of pesticides, except it has been scientifically proved and recommended.

5. Pesticides are prepared according to the recommendation, and have them homogeneously mixed prior spraying. Spraying shall be carried out in the morning or evening while the wind is calm, avoid the activity during strong sunlight or windy. During the operation the spraying operator shall be always on the windward side. Care shall be taken that pesticide spray mist shall not contaminate the adjacent plots and environment.
6. Prepare sufficient volume of pesticide mixture which is used up in one operation. There shall be no mixture left over in the spray tank.
7. After finish the pesticide spray, have the pesticide container rinsed 3 times with water which is poured into the spray tank and sprayed on planting plot that is approved in accordance with the recommendation on the label; or on designated area. This shall not cause any risk on contacting the produce or contaminating the water supply sources. The empty pesticide container shall be destroyed in order to prevent the reuse. It is discarded in the location provided for such specific container, or buried in the ground far away from water sources and living quarter by at least 50m, and with the depth that animals are not able to dig them up. Burning is prohibited.
8. After every pesticide spray, the operator shall change his or her clothes at once, take a bath shower and shampoo. The clothes shall be separated from the ordinary ones and cleanly washed.

9. Pesticide which is not used up in one operation, the container shall be tightly closed, and have it stored in the place provided for pesticides.
10. Different kinds of pesticides shall be kept in entirely concealed and secure place, protect them from sunlight and rain with good ventilation.
11. The storage of pesticides including other chemicals such as fuel shall be in good partition in order to prevent contamination of pesticides to produce and environment. Pesticide once opened shall not be transferred out of its original container.
12. Storage of each kind of pesticide is required to show legible label, and they are separately stored in categories, separated from fertilizers, plant growth regulators, different supplementary chemicals, and toxic substance protection equipment.
13. Pesticide storage place shall be fully equipped with accidental prevention equipment such as eye lotion, clean water, sand and fire extinguisher and etc.
14. Plant protection measures shall be proper for pest control, and it is on the basis of pest population surveillance.
15. Provide implementation of properly integrated pest management system in order to reduce pesticide use. Integrated pest management (IPM) means management system for pests by collecting details of pest population changes and the related environment. All proper methods and techniques are integrated together, and then operation is carried out to reduce the pest population level that does not cause economic damage.
16. Avoid the application of the same kind of pesticide repeatedly in order to delay pest s' resistance to pesticides.
17. Farmers and operators shall have the knowledge and the understanding of self-protection against hazard from chemical usage and the first aid.

18. Provision of recommendation articles on "what to do in case of accident or emergency" obviously displayed in the chemical storage area.

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