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Agricultural Pesticide Management in Thailand: Situation and Population Health Risk

Parinya Panuwet^a, Wattasit Siri Wong^b, Tippawan Prapamontol^c, P. Barry Ryan^a, Nancy Fiedler^d, Mark G. Robson^e, and Dana Boyd Barr^a

^aRollins School of Public Health, Emory University, Atlanta, GA, USA ^bCollege of Public Health Sciences, Chulalongkorn University, Bangkok, Thailand ^cCenter for Pollution and Environmental Health Research, Research Institute for Health Sciences, Chiang Mai University, Chiang Mai, Thailand ^dSchool of Public Health, University of Medicine and Dentistry of New Jersey, Newark, NJ, USA ^eSchool of Environmental and Biological Sciences, Rutgers University, New Brunswick, NJ, USA

Abstract

As an agricultural country and one of the world's major food exporters, Thailand relies heavily on the use of pesticides to protect crops and increase yields. During the past decade, the Kingdom of Thailand has experienced an approximate four-fold increase in pesticide use. This increase presents a challenge for the Royal Thai Government in effectively managing and controlling pesticide use based upon the current policies and legal infrastructure. We have reviewed several key components for managing agricultural pesticides in Thailand. One of the main obstacles to effective pesticide regulation in Thailand is the lack of a consolidated, uniform system designed specifically for pesticide management. This deficit has weakened the enforcement of existing regulations, resulting in misuse/overuse of pesticides, and consequently, increased environmental contamination and human exposure. This article provides a systematic review of how agricultural pesticides are regulated in Thailand. In addition, we provide our perspectives on the current state of pesticide management, the potential health effects of widespread, largely uncontrolled use of pesticides on the Thai people and ways to improve pesticide management in Thailand.

Keywords

exposure; health risk; legislation; management; pesticides; regulation; Thailand

1. Introduction

Situated in the peninsula of Southeast Asia with a tropical-monsoon climate, Thailand exports industrially processed food and agricultural products such as rice, cassava, rubber, corn, and tropical fruit. In 2009, agricultural products accounted for 9% of Thailand's gross domestic product (GDP), but their production used 40% of the workforce and 40% of the

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Corresponding author: Parinya Panuwet, MS, Ph.D. Assistant Research Professor, Department of Environmental Health, Rollins School of Public Health, Emory University, 1518 Clifton Road NE, Atlanta, GA 30322, office tel: 1+404-712-9028, fax: 1+404-727-8744, ppanuwe@emory.edu.

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land area. Despite this relatively small portion of the GDP, agricultural products made up approximately 19% of Thailand's total export value. Rural Thai people are heavily dependent on agriculture as their main source of income. As a result of the world economic recession, industrial sectors making up the largest proportion of the national GDP (40%) are declining while agriculture, a more reliable source of income, is increasing (OAE, 2010a).

Thailand relies heavily on pesticide use as a powerful tool for crop protection in order to increase production levels, product quality, and product appearance (HSRI, 2005). An estimated 50 percent of crops are lost to pests in the field without crop protection strategies (Oerke and Dehne, 2004). The use of pesticides in Thailand is therefore necessary and has increased significantly over time. The Office of Agricultural Economics (OAE) and the Office of Agriculture Regulation (OAR) showed that pesticide use increased by a factor of four in the last decade with more than 100,000 tons of active ingredients being imported into Thailand (Figure 1). Herbicides make up the largest proportion of imported pesticides, followed by insecticides, fungicides, plant growth regulators (PGR), and other groups of pesticides (OAE, 2010b; OAR, 2011). As a result of this extensive pesticide importation, Thailand ranked fourth out of 15 Asian countries in annual pesticide use and third in pesticide use per unit area (Walter-Echols and Yongfan, 2005). This increase in pesticide use is a result of many factors including insect resistance and resurgence of pests, industrialization of crop production, and conversion of crop type from one season to another to satisfy market demand despite changes in environmental conditions.

The Royal Thai Government (RTG) has been proactive in the management of hazardous chemicals by issuing and enacting its primary legal instrument, Hazardous Substance Act B.E. 2535 (1992) *amended B.E. 2544 (2001) and B.E. 2551 (2008)* (HSA), to control the use of chemicals and reduce chemical exposures and any related hazards and risks. Examples of hazardous chemicals being regulated under the HSA are corrosive and explosive substances, flammable chemicals, toxic substances, pathogenic substances, radioactive materials, and pesticides. According to the current report, there are 1,233 chemicals being regulated by the HSA (Danutra, 2004).

In this paper, we review pesticide management in Thailand. The benefits and limitations of the current regulatory processes in Thailand as well as specific health risks that may result from insufficient regulatory oversight will be discussed. Our intent is to highlight areas where improvement can be made to facilitate better management and use of pesticides in Thailand.

2. Classification of Currently Used Pesticides in Thailand by Hazard

Based on data from the OAR of the Department of Agriculture (DOA), about 70,000 tons of pesticides comprised of 265 individual active ingredients were imported into Thailand in 2010. Among these, the most imported insecticides were (from most to least imported) chlorpyrifos, fenobucarb, cartap hydrochloride, cypermethin, and methomyl. The most imported herbicides were glyphosate, paraquat dichloride, 2,4-D, ametryn, and atrazine. The most imported fungicides were mancozeb, sulfur, carbendazim, promineb, and captan. These pesticides accounted for around 75% of the total amount imported (OAR, 2011).

When classified based upon the WHO Recommended Classification of Pesticides by Hazard for the pesticides imported in 2010, five of the them were class Ia (extremely hazardous), 11 were class Ib (highly hazardous), 95 were class II (moderately hazardous), and the rest were either class III (slightly hazardous) or unlikely to present acute hazards in normal use (WHO, 2009). In all, about one third of the pesticides imported into Thailand in 2010 were either class I or II pesticides. It is interesting to note that several of the imported pesticides are not currently on the list of, "WHO Recommended Classification of Pesticides by

Hazard.” In addition to the acute hazards addressed by the WHO, some of the imported pesticides are classified as potential carcinogens or suspected endocrine disruptors (TOXNET, 2011).

3. Legal Body of Pesticide Management

The primary legal instrument used to regulate all hazardous chemicals, including pesticides, is the HSA. The purpose of this Act is to regulate the importation, production, marketing, and possession of all hazardous chemicals used in Thailand. It also aims to prevent hazardous exposures to humans, plants, animals, and the environment. Under this Act, the Hazardous Substance Committee (HSC) was set up as the governing body which assigned various aspects of governance to three Thai ministries; the Ministry of Industry (MOI), the Ministry of Public Health (MoPH), and the Ministry of Agriculture and Cooperatives (MoAC), based upon chemical usage. Figure 2 shows the shared responsibility of various agencies (at the department level) for pesticide use regulation. The ministry’s further divided regulatory functions render Thai pesticide regulation fractured and inefficient.

Each responsible agency, depending upon the level of authority given to them, can issue ministerial regulations and notifications to facilitate compliance with the HSA, which primarily oversees 1,233 chemicals (Danutra, 2004). It is challenging for each responsible agency to establish specific actions needed to comply with *the broad focus* of this Act because each group of regulated chemicals has different chemical properties, availability, and use patterns. Because of the broad inclusion of vastly different chemicals in the HSA, it *alone* is unlikely to be able to effectively regulate all these chemicals as planned by the RTG. This regulation’s lack of focus on specific chemical groups has made full compliance difficult, if not impossible. Moreover, because the end-users for each group of chemicals are different, an enforced uniform system aiming to control all of the chemicals would have to lack specific regulatory guidance, rendering it neither practical nor effective. On the other hand, a specific system with narrowly defined groups of hazardous chemicals would facilitate stricter regulatory guidelines, enabling the proper management of hazardous chemicals, including pesticides. In fact, the HSRI (2005) also noted that shared responsibility between agencies results in a general lack of ownership over the regulatory enforcement process, and renders the process fragmented and opaque. In addition to the HSA, other supporting legal instruments have been enacted to facilitate the management of hazardous chemicals including pesticides (see Table 1 in supplementary material).

4. Domestic Pesticide Registration, Production, Distribution and Sale

The regulatory process for registration, production, distribution, and sale of pesticides used in crop production is currently being controlled by the DOA of the MoAC which has released two main regulations:

1. Notification of Ministry of Agriculture and Cooperatives on Registration, License Issuance and Renewal of Hazardous Substances under the Responsibility of Department of Agriculture B.E. 2552 (2009)
2. Notification of Ministry of Agriculture and Cooperatives on Production, Importation, Exportation and Being in Possession of Hazardous Substances under the Responsibility of Department of Agriculture B.E. 2547 (2004)

Presently, there are approximately 400 active ingredients (AI), that include formulations with differing percentages or combinations of AIs, registered for importation. Over 20,000 pesticide formulations (accounting for 80% of all pesticides used in Thailand) are licensed for production (Danutra, 2004; OAR, 2011). The certificate of pesticide registration lasts for six years and can be renewed upon expiration. The registration process of new pesticides

includes efficacy testing and analysis of their chemical and toxicological properties. The responsibility for efficacy testing is put upon manufacturers and must be performed according to an experimental design approved by the Office of Plant Protection Research and Development (OPPRD) of the DOA. Recent regulations require that new pesticides must undergo evaluation of pre-harvest intervals (PHIs) and maximum residue limits (MRLs) under supervision of the Office of Agricultural Production Science Research and Development (OAPSRD) prior to registration being granted. Presently there are 1,504 pesticide products that have established PHIs (OAR, 2011).

Problems regarding pesticide regulations often involve the management of existing or registered pesticides (HSRI, 2005). Because the HSA was broadly defined to include the control of *all* hazardous chemicals without intentionally considering end use, areas of particular importance to the effective regulation of pesticides are not covered. For example, the HSA relies heavily on the industry itself for chemical management, from importation until the point of sale. Much of the misuse and mishandling of pesticides occurs after the point of sale, thus leaving pesticide use largely uncontrolled.

The HSA does not provide the DOA a complete regulatory guidance for domestic sale of pesticides (e.g. advertisement, use of trade name, or sale restriction) therefore making it difficult to control domestic trading. Because the market for pesticides within Thailand is competitive, pesticide wholesalers advertise with tempting commercials featuring sales promotions or incentives that can easily entice their use (Chatiket, 2005; HSRI, 2005). At present, there are over 26,000 retailers who are licensed to directly sell (with no restriction except they must correctly provide product information) agricultural chemicals including pesticides to any buyers or farmers as long as the products are legal to sell. However, many more unlicensed pesticide retailers exist. Due to the large number of unlicensed retailers, the point of sale is ineffectively controlled, resulting in the purchase of unregistered pesticides, substandard pesticide solutions, and the sale of prohibited pesticides (OAR, 2011; HSRI, 2005).

Another challenge in controlling the point of sale is the numerous trade names for the same or similar products. Trade names are loosely controlled by current legal instruments; one chemical can have multiple trade names making control of the active ingredient difficult. Currently, over 20,000 pesticide formulations are sold in Thailand. In addition, some single-ingredient pesticides may have as many as 300 different trade names, making the control of usage and the maintenance of a chemical inventory difficult. This also makes the education of end users nearly impossible (OAR, 2011).

5. Pesticide Surveillance, Evaluation, and Control

The evaluation of pesticide quality is the responsibility of the OAR of the DOA. Samples from the markets and at ports of entry are taken and analyzed by laboratories at the OAPSRD. The percentage of active ingredients must conform to the percentage proposed for registration. In 2010, the OAPSRD reported that of the 767 samples that were analyzed, only 2 samples were considered substandard (OAR, 2011).

The DOA of the MoAC requires that pesticides with high acute toxicity ($LD_{50} < 30$ mg/kg) be evaluated using surveillance. Presently aldicarb, blasticidin-S, carbofuran, dicotophos, ethoprophos, formetanate, methidathion, methomyl, oxamyl, and ethyl p-nitrophenyl thionobenzenephosphonate (EPN) are under evaluation. If surveillance suggests a pesticide has a severe adverse impact on human health or the environment, the DOA of the MoAC will take action to ban or severely restrict the pesticide (Chunyanuwat, 2005; OAR, 2004).

The DOA of the MoAC has recognized the overuse of pesticides and attempted to reduce usage amounts by launching mitigation campaigns including organic farming, integrated pesticide management (IPM), good agricultural practice (GAP), and promoting the use of bio-pesticides. These policies are implemented with limited support from legislation or infrastructure (Choengthong and Charernjiratragul, 2004; Kerdchoocheun, et al., 2005; IPM-DANIDA, 2009). Many farmers, as end users, still believe that pesticide application is necessary and the level of protection derived from pesticides is proportional to the amount applied. Consequently, continued use of large amounts of pesticides is likely, unless a successful campaign is conducted that educates farmers, changes their attitudes about pesticides, and makes them cognizant of regulatory controls and proper pesticide use (Chalermphol and Shivakoti, 2009; Janhong, et al., 2005; Plianbangchang, et al., 2009).

6. Illegal Use of Pesticides

The HSA has given authority to the HSC to prohibit the importation, production, and use of registered pesticides that are extremely (class Ia) or highly toxic (class Ib) to humans and animals or are potential carcinogens, including those that are organochlorine pesticides (OCs). At present, 98 pesticides are prohibited for use on crops in Thailand, making it the Asian country with the largest number of banned pesticides. These include, but are not limited to, three recently banned pesticides; methamidofos (banned in 2003), methyl parathion, and all active isomers of endosulfan (banned in 2004) (OAR, 2004).

Despite the prohibition process and public announcements regarding the bans, enforcement is rather weak. Numerous reports have shown the use of prohibited pesticides continues throughout the country. These reports include documented evidence of the continued use of endosulfan, methamidofos, parathion-methyl, and monocrotofos (Panuwet, et al., 2008; Panuwet, et al., 2009b; Sriprapat, 2004; Plianbangchang, et al., 2009). The primary reason prohibited pesticides are still used in agriculture is that they are effective in controlling pests, and thus, are still in high demand from farmers. The DOA of the MoAC has recognized this problem and made a concerted effort to enforce existing regulations, but struggles to find the most appropriate resolution. Because these pesticides were once very popular and were available with over a hundred trade names, control and monitoring after prohibition is difficult. This is especially a problem when the number of officers responsible for enforcing the regulations is far fewer than the number of suppliers. Reports have revealed that these pesticides are not only illegally stocked by traders, but are also illegally smuggled across the border for domestic use (HSRI, 2005).

7. Controlling Pesticide Contamination in Agricultural Products and Food

In 2004, the RTG unveiled their national policy on food safety to improve the quality of food produced for domestic consumption and **most of all** for exportation. By integrating all available infrastructures and agencies, the *National Road Map of Food Safety* (the “*Road Map*”) was developed as a guideline for quality control measures in each stage of food production (Srithamma, 2010). Interestingly, this policy focused heavily on reducing and monitoring pesticide residues in agricultural products and food. Figure 4 summarizes the regulation scheme to accommodate the “*Road Map*.” At the farm level, pesticide use is overseen by *Good Agricultural Practice (GAP)* policy established by the DOA of the MoAC. Also seen in Figure 4, there is dual **enforcement of MRLs** using two sets of MRLs, some of which differed substantially for the same pesticide or crop. For example, the MRL for chlorpyrifos in okra is 0.5 mg/kg based on the TACSFI’s regulation, whereas the MRL of 0.1 mg/kg is enforced based on the MoPH’s regulation. Also, there are 15 MRL values established for chilis based on the TACSFI’s regulation but only 6 MRL values are being

enforced by the MoPH. These conflicting regulations cause substantial confusion and may result in overall ineffective pesticide management strategies.

Monitoring of pesticide residues and enforcing the MRLs are challenging for the responsible agencies particularly when relying on the use of non-quantitative, rapid colorimetric assay kits. The DMSc of the MoPH has developed several assay kits capable of detecting several pesticides in four main classes (organophosphate, carbamate, pyrethroid, and organochlorine). Some of the kits use an enzyme cholinesterase (ChE) inhibition-based colorimetric technique, while some use regular enzyme-linked colorimetric techniques or thin layer chromatography (TLC). Although the reported validation results of these kits are impressive (e.g. accuracy 93%, sensitivity 98%, and specificity 79%) (Leuprasert et al., 2010), several limitations must be addressed particularly when using ChE inhibition-based colorimetric assays designed for monitoring of organophosphate (OP) and carbamate pesticides, particularly their inability to detect low levels of enzyme activity depression. Although the ChEs are inhibited by toxic chemicals such as OP and carbamate pesticides, the degree of inhibition caused by each individual pesticide is different, making proper identification of the assaulting pesticide difficult. Also, some OP and carbamate pesticides have nearly no or little inhibitory effect on ChE in their pure form (Andreescu and Marty, 2006), thus, the use of this assay may not be able to detect the presence of such chemicals in samples potentially creating false negative results. Moreover, the majority of the currently enforced MRLs are, in actuality, the minimum level of detection of the test kit, making the analysis results somewhat unreliable. In addition, some particularly harmful pesticides such as bis-dithiocarbamates and triazine herbicides cannot be detected using the available assay kits. Thus, it is difficult, if not impossible, to enforce the MRLs using these test kits. Unfortunately, the Thai FDA relies heavily on using these test kits to monitor pesticide residues in agricultural products and to determine the suitability of importation of agricultural products at the point-of-entry into Thailand (Rakariyathum and Kaosa-ad, 2010).

A recent report from the FDA of the MoPH indicated that 3.25 percent of 54,140 fresh food samples available in local markets in 2009 were contaminated with pesticide residues exceeding a safety threshold (not necessarily above or below MRLs) (FDA, 2009). These data, however, were primarily generated using qualitative colorimetric assay test kits. These data may indicate the success of *food safety* policy or may represent an underestimation of the safety threshold violations because of the general insensitive and nonspecific results obtained from these types of assay kits or from the degradation of pesticides in the samples tested.

Although this is a very realistic attempt for the RTG to monitor and screen pesticide residues in fresh food for domestic consumption and importation; the DMSc and FDA of the MoPH should attempt to expand their laboratory capacity such that more selective and sensitive monitoring of pesticide residues in fresh food can be regularly made, for example, using advanced, sensitive, and selective techniques such as gas chromatography-mass spectrometry (GC-MS). Unfortunately, the limited financial, human, and laboratory resources available to these agencies likely means that the rapid, less-sensitive test kits will continue to be used in national screening activities.

Unlike the FDA of the MoPH, the TACFSI of the MoAC enforces its MRLs using results generated from GC-MS. Because this institute oversees the quality of food products for exportation, standard MRLs have to be met prior to shipping to the countries of destination. Although this agency uses highly selective and sensitive techniques for enforcing MRLs, it is not specifically tasked with enforcing MRLs for food for domestic consumption, particularly locally produced food from small-scale, traditional farms.

8. Controlling Pesticide Contamination in Water

The regulation of pesticide contamination in water falls under the Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992). Under this Act, the National Environment Committee (NEC) was formed to establish regulatory instruments (Table 1) that seek to limit the maximum residues of pesticides in surface and groundwater (see details in Table 2 in supplementary material). One study found detectable levels of atrazine (0.058–0.086 µg/L) and endosulfan in water samples collected from the Chao Praya River, the main river in Thailand (Kruawal, et al., 2005). Aiemsupasit (2005) reported detectable levels of OP (<0.01–5.47 µg/L), carbamate (<0.01–13.67 µg/L), and pyrethroid (0.05–0.04 µg/L) pesticides in rivers across Thailand. These pesticides are not regulated under the current instruments, except atrazine which is only regulated in ground water.

9. Occupational Health Problem

9.1 Acute exposure and effects

OPs have become the most abundantly used insecticide group in Thailand. They exhibit their acute effects by inhibiting the function of the nervous system enzyme acetylcholinesterase. The most commonly used OPs in Thailand are chlorpyrifos, dichrotofos, parathion methyl, and profenofos (Sematong, et al., 2008; Jaipieam, 2009a; Taneepanichskul, 2010; Norkaew, et al., 2010).

Acute effects from OP exposure include pulmonary edema, cyanosis, muscle spasms and weakness, blurred vision, respiratory difficulty, and possibly death due to respiratory failure (US EPA, 1999). Several research studies have documented that, as a result of frequent exposure to OPs, Thai farmers have reported developing these symptoms, as well as nausea/vomiting, tearing, numbness in hands and feet, and chest pain (Jaipieam, et al., 2009a,b; Norkaew, 2010; Taneepanichskul, et al., 2010). Most of these symptoms, although recognized as effects of poisoning, are reversible therefore farmers are unlikely to seek medical attention and often go unreported. Thus, the numbers depicted in Figure 3 may not represent the full extent of OP poisonings among Thai populations (HSRI, 2005; Siripanich, 2008).

9.2 The Use of Personal Protective Equipment (PPE)

Surveys evaluating the knowledge, attitude, and practices (KAP) in Thailand revealed that knowledge of the harmful effects of pesticide exposure and safe use methods differed by crop and farming activity. Although farmers generally understood the potential lethality of pesticides, their attitudes toward pesticide use as well as knowledge and use of PPE were poor (Norkaew, et al., 2010; Wongwichit, et al., 2010). For example, about three-fourths of chili farmers located in the northeastern region of Thailand who were surveyed about their KAP did not understand the utility of PPE, did not use PPE, or were not concerned about their overall exposures (Norkaew, et al., 2010). The general lack of PPE use by Thai farmers puts them at increased risk of pesticide exposures and health outcomes related to those exposures (Panuwet, 2008).

9.3 Potential health risk of chronic pesticide exposure

Although most OCs were phased out gradually in crop production beginning in the late 1970s, their legacy remains in the environment, wildlife, and humans (Thirakhupt, et al., 2006; Siriwong, et al., 2009a,b). Siriwong, et al. (2008) found residual levels of several OCs in ng levels in water, sediment, and aquatic organisms collected in an agricultural region of central Thailand demonstrating their persistence. They also postulated that locally caught fish, freshwater prawns and snails, swamp morning glory, and water lilies found in the

region may pose an exposure risk to chemicals, such as α -, β -HCH, heptachlor, heptachlor epoxide, aldrin, dieldrin, DDD, DDE, and DDT, if consumed. In fact, cancer risk of greater than one in a million was estimated in fishermen throwing and/or placing a fish net in the water in central Thailand because of the presence of and exposure to dieldrin, DDT, β -HCH, heptachlor, and heptachlor epoxide in the canals (Siriwong, et al., 2009a). This highlights the growing body of literature that has found elevated risk of various cancers related to exposures to OCs (Robson, et al., 2010).

Health outcomes were also observed after chronic exposure to current-use pesticides. In 2009, the DMSc of the MoPH launched a nation-wide chronic health impact assessment among 1,217 farmers (aged 18–65 years) who were currently applying pesticides (n=734) and who had not used pesticides for at least one year (n=483). Farmers who were currently applying pesticides had an increased occurrence of DNA strand damage than those who were not currently applying pesticides (CFSI, 2011).

10. Pesticide Exposures among Children

Due to physiological and behavioral differences, pesticide-related exposures and health effects among children are different, and often worse than exposures among adults. Children differ substantially from adults in terms of exposures, physiological factors, pharmacokinetics, metabolic efficiency, membrane permeability, binding and storage of xenobiotics, and pharmacodynamics (Needham and Sexton, 2000). Children are also genetically susceptible to OP toxicity due to low paraoxonase (PON1) gene activity. This suggests that OP exposures may have a greater impact on the growth and development of children than adults exposed to similar concentrations (Huen, et al., 2010).

Due to widespread pesticide use across the country, Thai children are exposed to high volumes of different classes of pesticides that may synergistically contribute to developmental effects, as documented in numerous current birth cohort studies (Rauh, et al., 2011; Engel, et al., 2011; Bouchard, et al., 2011). Additionally, children of farmers have unique para-occupational exposures resulting from using their parents' workplace as their playground. Three studies have shown that Thai children (aged 4–15) have higher pesticide exposures, assessed through biomonitoring of urinary pesticide metabolites, than those in other countries such as the United States (Panuwet, et al., 2009a,b; Petchuay, 2006). In fact, Thai children's urinary metabolite levels are approximately double those found in U.S. children. Throughout their lives, Thai children may be exposed to pesticides in various ways. This risk is compounded by ineffective pesticide management in Thailand (Panuwet, 2009a,b).

11. National Master Plan on Sound Chemical Management

In response to increasing health problems caused by chemical exposures and following the country's participation in the International Programme on Chemical Safety (IPCS), the RTG has appointed a National Coordinating Committee on Chemical Safety (NCCCS), with the FDA serving as the secretariat responsible for developing the National Master Plan on Chemical Safety (NMP). The NMP was formulated to strengthen the coordination of policies and plans regarding chemical safety of all concerned agencies with an emphasis on optimization of resource utilization to reduce impacts on humans and the environment. The first NMP on Chemical Safety was approved by the Cabinet in 1996 and was implemented from 1997–2001. Following the end of the first plan, the second NMP was implemented consecutively during 2002–2005. The strengths of these plans were: (1) a comprehensive approach to integrate all agencies involved in pesticide regulation to use their information to develop a body of knowledge and human resources including administrative infrastructure for better chemical management, (2) development of national networks of chemical

information and poison centers, (3) development of emergency response and preparedness to prevent and handle chemical accidents, (4) promotion and strengthening national capacities and capabilities in chemical waste management, and (5) encouragement of research and development regarding chemicals and chemical safety (Hesakul, et al., 2006; NCCCS, 1997).

The third NMP called the National Strategic Plan on Chemical Management (NSPCM) (2007–2011) was released and implemented by the National Strategic Committee on Chemicals Management (NSCCM, Former NCCCS) to continue building on the first two NMPs. This plan focused on a multi-disciplinary approach to manage chemicals throughout their life-cycles by reacquiring all inter-ministerial cooperation. It focused on chemicals used in the agricultural sector and other industrial chemicals of high concern that currently threaten human safety and quality of life. This plan, in particular, sought to reduce chemicals used in the agricultural sector, support organic practice and export of organic produce, establish strict control over agricultural chemicals that are banned by other countries, and establish a controlling system over advertisements and sales promotion of agricultural chemicals (NSCCM, 2007).

Although the establishment of NMPs with inter-ministerial composition seemed to be a perfect model for chemical management in Thailand, the success in its implementation has not yet been proven. Currently, the committee is comprised of 20 government organizations, 10 academic institutions, 10 non-profit civil societies, and 10 industry representatives--certainly a large committee whose size will likely hinder its effectiveness. The lack of harmony among all participating stakeholders, scant information retrieved from their endeavors, and lack of support from policy makers are hindering the success of the last NMP and have made it more difficult to translate into action or legislation (Hongsamoot, 2009). Another problem is that even though the third NMP promises to revise some regulatory enforcement, it does not seem to have specific content on how legislation will be changed regarding the control of use and trade of agricultural chemicals. We believe that as long as pesticide management and infrastructure continue to be framed under the auspices of the HSA (1992), complete management and control of pesticide use and trade practices cannot be done easily or effectively.

12. Conclusion and Recommendations

We reviewed several key components established to manage agricultural pesticides in Thailand, including its current policies and legal infrastructure. We found that one of the main obstacles to effective pesticide regulation in Thailand is the lack of a consolidated, uniform system designed specifically for pesticide management. The fact that pesticides are primarily regulated under the HSA, together with the other distinctive hazardous chemicals, has weakened the enforcement of existing regulations, resulting in several problems and subsequent increase in environmental contamination and human exposures. Thus, the health risk of Thai people is potentially elevated due to the current management scheme.

Because Thailand is, and will continue to be, a major agricultural exporter, Thai agricultural products are an important part of the Thai economy. Increases in Thai agricultural exports have resulted in the demand for and higher use of agricultural chemicals. Unless there is a substantial change in recognizing the limitations of the current pesticide management strategies and moving forward to create a more uniform system designed specifically for pesticide management, the RTG will continue to face challenges in regulating and managing the increased importation, manufacture, and distribution of pesticides into the country and in regulating pesticide use at the farm level.

Additionally, other non-regulatory components also need to be in place for controlling pesticide use at farm levels. Guidance on the proper use of pesticides should be made available from suppliers, the DOA of the MoAC, and academic institutions. The information should include careful use and application techniques, as well as information regarding the inherent toxicity of these chemicals. Pesticide product selection recommendations and product safety information are critical components of good pesticide stewardship and efficacious pesticide use. Proper and judicious use of pesticides will result in even greater production without compromising the sustainability of the Thai agricultural system and human health. In addition to focusing on increasing crop production, human and ecological health must be considered. Ministries must work in a coordinated fashion with academic institutions to train farmers to be targeted and relevant to their climate and crop rather than providing information that is repetitive and potentially irrelevant.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- We have reviewed the policies and legal instruments enacted to manage agricultural pesticides in Thailand.
- One of the main obstacles to effective pesticide regulation in Thailand is the lack of a consolidated, uniform system designed specifically for pesticide management. This deficit has weakened the enforcement of existing regulations, resulting in misuse of pesticides, and consequently, increased environmental contamination and human exposure.
- We provide our perspectives on ways to improve pesticide management in Thailand.

Figure 1.
Summary of Imported Pesticides

Figure 2.
Regulatory Body of Hazardous Substance Act B.E. 2535 (1992) amended B.E. 2544 (2001)
and B.E. 2551 (2008)

Figure 3.
Report cases of pesticide poisoning per 100,000 populations in Thailand

Figure 4.
Food Safety Regulation Scheme