Southeast Asian Studies, Vol. 42, No. 2, September 2004

Agropesticide Contract Sprayers in Central Thailand: Health Risks and Awareness

Somluckrat GRANDSTAFF* and Waraporn SRISUPAN**

Abstract

Chemical agropesticide use in Thailand has been on an ever rising trend. As the process of agricultural intensification evolves, a large number of rice farmers in the irrigated area in Central Thailand no longer apply chemical agropesticides themselves but instead have been hiring others to do the task. This report describes the results of a study of the agropesticide contract sprayers. They were found to work both individually and in groups/teams, primarily on rice, but also on some other crops as well. Many had been contract sprayers much longer than five years which they themselves said should be the reasonable maximum. Virtually all had experienced acute pesticide poisoning to varying degrees, and a large majority had experienced one or more incident of being "knocked out by the drug." Most contract sprayers recognized that pesticide injury was serious and tried to protect and take care of themselves as best they could. However, both safety measures and treatments taken were clearly inadequate, seemingly because of several interacting factors: inadequate knowledge and awareness, lack of bargaining power, difficult local conditions, use of highly hazardous pesticides, and inadequate medical monitoring and treatment capabilities. Remedial actions are suggested.

Keywords: Thailand, rice, pesticide poisoning, health awareness, agropesticide, mechanization

Over the past quarter century, use of chemical agropesticides in Central Thailand has continued to increase. In 1978, 47% of agricultural households in this region reported using

———————————————————

* PO Box 1103, Kasetsart Post Office, Bangkok 10903, Thailand

** Faculty of Social Sciences and Humanities, Mahidol University, Salaya, Nakhon Pathom 73170, Thailand

Maliwan Tanglakavanich, Saipin Kaewchiduang, Sumang Pluemcharoen, Natawan Udomsuk and Veera Ket-hom carried out major portions of the fieldwork. Sompool Kritalugsana, MD, Institute of Toxicology, Siriraj Hospital, Mahidol University, Suphachat Sukharamana, Faculty of Economics, Kasetsart University, and Suwimol Lerdweerasirikul, Division of Agricultural Toxic Substances, Department of Agriculture, assisted in the study. Pisit Wattanavitukul, MD, was also consulted. Note: neither author is a medical doctor, no medical doctors have proofed this report, and none should be held responsible for any interpretations in it. Fieldwork for this study was funded by a Rockefeller Foundation grant to the Thailand Development Research Institute. This report was edited by Terry B. Grandstaff.

chemical pesticides on their crops. By 1983 this rose to 65%, and to 73% in 2003. In the same region, the number of mistblowers, the most commonly used pesticide spraying machine, increased 10 times between 1978 and 1993 alone—from 25,000 to 254,000 machines [Thailand, NSO 1978, 1983, 1993a, 2003].[1)]

Much agropesticide application in Central Thailand is on intensively cultivated rice crop land. When water conditions allow, as they often do, rice is grown virtually year-round on large areas in this region.[2)] But many rice farmers in the region no longer personally apply pesticides themselves. Instead, they hire others to carry out this task. As will be discussed below, this has been a significant factor in allowing many farmers to continue growing rice, but it has also created health hazards for those who took up agropesticide spraying as a profession.

This report summarizes the results of research on agropesticide contract sprayers in an area of Central Thailand in 1991–92.[3)] We wanted to better understand the transition to contract spraying and its role in the larger agricultural system, how contract sprayers worked, and especially the health, and health awareness, implications for the contract sprayers themselves. Although the field data were collected in the early 1990s, the use of pesticides in Thai agriculture has continued to increase and the sprayers are probably in just as much if not more danger today. For example, “Pesticides remain weapon of choice” [Wangvipula 2004: 7]. And “Problems related to hazard of pesticide use are increasingly serious and widespread . . . the majority of farmers . . . does not comply with use instruction on the pesticide containers” [Anonymous 2003: 1].[4)] The findings also have important implications for other regions and other countries experiencing similar transitions.

Study Procedure

The research issue suggested the need for a methodology that was iterative and progressive, to respond to information as it was being learned. The study mainly used semi-structured interviewing, direct observation, and other related techniques.[5)] Key informants

1）In this report, whenever the type of spraying machine is not specified, the machine is the mistblower: a motorized backpack sprayer powered by a gasoline + oil engine fitted to an impeller fan [*e.g.*, Sutherland 1980; Ratanasathien 1995]. Others mentioned are specifically named: high-pressure hydraulic pump sprayer, and manual (hand-pumped) knapsack sprayer.

2）For example, in the 1994–95 crop year, Central Thailand, with only 17% of the country’s total rice land, had 52% of the country’s total area under off-season rice [Thailand, NSO 1996: 89–90].

3）Fieldwork was carried out in 8 days in April–December 1991 and 10 days in October–November 1992. Initial findings were reported in Srisupan [1993].

4）For further evidence: Thailand, Epidemiology Division annual reports [*e.g.*, 1998] and Grandstaff [1996: 10].

5）Semi-structured interviewing uses conversational guidelines rather than a questionnaire. For more information about these types of techniques, see Grandstaff and Grandstaff [1987], Grandstaff and Messerschmidt [1995], and Yin [1994].

included village headmen, assistant headmen, agricultural and health extension officials, shopkeepers, and some of the contract sprayers themselves. These were interviewed to obtain a broad picture of contract spraying in the study areas. Individual respondents were contract sprayers and field owners who hired them, who were interviewed about their own personal experience.[6] Interviewees were selected to represent geographical areas with different natural resource conditions and other factors that might affect pesticide-related behavior. Other sources of information included discussions with medical doctors and toxicological experts.

The main study sites were in irrigated rice-growing area in two districts, Donchedi and Sriprachan, in Suphanburi Province. Suphanburi was chosen because, compared to other provinces, it had the largest rice growing area in Central Thailand. The particular sites were chosen based on analysis of official documents and key informant interviews which indicated extensive chemical pesticide use and a large number of contract sprayers. For comparison, the study also covered contract spraying in other locations in the province: (1) the rainfed area in Donchedi District; (2) the low elevation area in Bang Plama District where many rice fields were under standing flood for a long period each year; (3) the irrigated area in the district of Derm Bang Nangbuaj where land is higher in elevation and some distance away from the main irrigated study sites; and (4) Wang Luek Subdistrict, in Samchuk District, where sugarcane fields accounted for over 30% of its total agricultural area.

In Suphanburi, rice accounted for 64% of total crop land [Thailand, NSO 1993b] and the study emphasized contract spraying on rice, but rice was not the only crop worked on by the contract sprayers. Contract spraying on other major crops, including sugarcane, corn, water chestnut and vegetables, was studied for an accurate picture and scope of the activity.

Among the first things learned was that contract sprayers operated in groups as well as taking contracts individually. Interviews were thus conducted with both types of sprayers.

The Development of Contract Spraying

According to farmers, contract pesticide treatment started long ago in the study areas, but significant expansion, and the emergence of contract sprayer groups in particular, noticeably began around the mid-1980s. Groups (*choom*) started from 2–3 members who each owned a power mistblower. At first there were few such groups, but their number and size rapidly increased, especially following the brown planthopper epidemic of 1989–90.

Contract spraying occurred as a part of a farming intensification process wherein mechanization is increasingly involved and people owning and operating farm machines are hired to perform specialized tasks. Statements by various farmers illustrate some of the major

6) In this report, following interviewees' terminology, "field owner" means the person who managed the field and hired the sprayers, not necessarily the legal owner of the land.

changes in this evolving process. “Short rice [high-yield] varieties were first adopted in this area around the mid-1960s and they need more chemical fertilizers and pesticides.” “I switched from buffaloes to mechanical plow [in the early 1970s], and from transplanting to broadcasting about 4–5 years later.” “Even for land preparation, I am already hiring people to plough the land . . . and I am thinking of contracting a mechanical harvester next year . . . .”

The new nonphotoperiod-sensitive varieties could be grown year-round, and irrigation provided the opportunity to grow them in the “off season.” Rice production in the irrigated area has become a continual activity when water conditions allow. “We can’t tell which is the wet season rice and the dry season rice any more . . . when water was good, we grew five crops of rice in two years.” Under such conditions, pests became much more numerous and persistent, and the need for mechanized pesticide application arose.

Once machine pesticide spraying was widely adopted for rice fields, contract spraying greatly expanded, and contract groups formed. The vast majority of members of contract sprayer groups worked primarily on rice, where team labor was deemed necessary for herbicide treatment. Weed control treatment at the beginning of each rice cropping period is probably the busiest time for contract sprayers. It must take place at about the same time (when the water is released) among a large number of fields.

Both field owners and contract sprayers consider herbicide spraying to be delicate work that must be very thorough. “You have to cover every square inch adequately.” Otherwise, “weeds will grow and tell-tale on your being unprofessional” and “they will hire someone else next time around.” Working in a team was necessary because “it is easy to miss spots” and “walking around there by yourself, sometimes you can’t remember where you have and haven’t sprayed.” A single sprayer cannot cover a very large area at a time and many farm households could not do this kind of herbicide application by themselves. For many households, “just the parent generation works in the field—the children are in school, some older ones work in the city, some are going to university. . . .” With decreasing family labor (and disappearing exchange labor), many field owners instead hired a contract team.

After herbicides, insecticides are needed in the rice growing cycle. According to farmers, beginning when the rice plants are about 20 days old, insecticides must be applied 3–4 times prior to the rice flowering, and more often than this if there was an insect pest epidemic. However, the timing for most insecticide application can be somewhat flexible, and some rice farmers preferred to apply insecticides themselves if they were able to and believed they could do it more thoroughly themselves.

Nevertheless, with such intensive cropping conditions and family labor limitations, an increasing number of field owners came to rely heavily on contract sprayers for both herbicide and insecticide treatment, and not just the large farmers. Some farmers who could not afford a spraying machine hired contract sprayers instead. Most woman field owners hired sprayers. Some field owners believed contract sprayers had better knowledge and experience dealing with strong chemicals. Some had prior pesticide poisoning or current ill health: “I can’t take it any more, sometimes I feel sick and dizzy even when people are spraying at

quite a distance." Or simply: "I am too old for this." Another concluded that "they make it possible for old farmers like me to go on with rice farming for a while or I would have had to quit already . . . now I am not a hands-on farmer, just a manager."

Contract Sprayers and Sprayer Groups

In the study areas, almost all contract sprayers were local men in regular farm families, who took up contract spraying as a secondary occupation. Among those interviewed, the average age was 34 years, the youngest 21, the oldest 60 (Table 1). Average age entering the profession was 29, the youngest 17. The person working the longest in this profession had been in it for 18 years. Average time was 5 years, but nearly one in five persons had been in for more than 10 years. As will be discussed below, most of these sprayers had experienced symptoms of acute pesticide poisoning, and one or more episodes of what they described as "*knock ya*"—passed out, unconscious, "knocked out by the drug."[7)]

As mentioned above, contract sprayers operated both individually and in groups.

Individual Contract Sprayers

Contract sprayers without their own machines worked alone, paid only for their labor. They were found throughout the study areas. If the field owner did not have a machine, one could usually be rented. These contractors tended to be landless agricultural laborers. It was also common for them to grow crops on rented land. Some were farmers from the rainfed area where only one rice crop could be planted annually.

Many farmers with their own rice land bought used or new mistblowers initially for their own use, and then also sold their services to others. Some did not intend to become contractors but "once I finish with my own fields, friends and neighbors tend to come around and ask for help . . . can't say no because I see them all the time . . . might as well just work for a fee, we both feel easier."

Some farmers with their own machines had enough work just taking care of their own fields. In one village, low compensation was cited as the reason for few contracts among relatives, and one key informant also said contract spraying was less frequent in villages where cooperation among relatives and neighbors (exchange labor) was still good.

Sprayer Groups, Operating in Teams

Most rice contract sprayers organized themselves into groups (*choom*) and worked in teams, using mistblowers. This increased their opportunity for work, even though working almost exclusively in rice. As discussed above, mistblower teams were preferred for herbi-

7) "*Knock*" is spelled here like an English word to better convey the meaning. "It means knocked out, just like in boxing."

Table 1　Profile of 39 Contract Sprayers Interviewed

Interviewee	Group Size	Age Range	Age Start	Age Current	Years at Work	"*Knock*" (*Times*)	Drug Use
Group 1	9	29–45	24	26	3	1	yes
			24	29	5	1	yes
Group 2	8	26–50	48	50	2	1	yes
			28	30	2	1	yes
Group 3	7	30–41	31	40	9	2	yes
			25	26	1	1	ni
Group 4	7	26–40	32	33	1	1	yes
Group 5	6	21–39	25	39	14	3	no
			18	22	4	1	no
			20	21	1	ni	ni
Group 6	6	30–45	27	30	3	2	yes
Group 7	6	28–42	34	39	5	1	yes
Group 8	6	30–40	36	39	3	1	yes
Group 9	5	20–31	30	31	1	1	yes
Group 10	5	28–36	27	30	3	1	yes
Group 11	4	ni	30	45	15	2	yes
			38	39	4	ni	no
Group 12	4	30–41	28	35	7	1	ni
Group 13	4	20–60	57	60	3	ni	yes
Group 14	3	25–43	36	39	3	2	yes
			41	43	2	1	yes
			22	25	3	1	yes
Group 15	3	28–37	17	28	11	3	ni
			19	22	3	ni	no
			25	36	11	2	ni
Group 16	3	33–39	37	39	2	3	ni
			20	24	4	0	no
Group 17	2	25–40	23	40	17	2	yes
			22	25	3	1	yes
Individual Sprayers (not members of Groups)			31	34	3	0	yes
			37	41	4	ni	no
			36	37	1	1	yes
			33	35	2	1	ni
			22	34	12	3	ni
			21	26	5	2	ni
			26	30	4	1	ni
			23	41	18	3	ni
			20	22	2	1	ni
			28	32	4	2	ni
Average	5		29	34	5.1	1.5	

Source: Field interviews of contract pesticide sprayers, Suphanburi, Thailand, 1991, 1992.

Notes: 1) Percent of sprayers ever experienced "*knock*" : 94%; percent of sprayers taking drugs: 76%.

2) Current =1991–92; ni=no information, excluded from calculation.

cide application and many field owners hired them for insecticide treatment, too. A team is also required to operate a high-pressure hydraulic pump sprayer preferred by some field owners.

Most group members already had a mistblower for their own use and many had also first contracted individually. One farmer started working individually, paid only for his labor. After 4–5 years, he bought a used mistblower. Later, with increased experience and a build-up of a clientele, he invited his younger brother who also bought a used mistblower to join him and form a group.

Among those interviewed, the largest group had 9 members, and the largest heard of had 15. The group size most frequently encountered was 6 (Table 1). Sprayers worked in teams of 3–5 persons, with insecticide teams normally smaller than for herbicides. It was not uncommon for a group, especially a larger group, to send out more than one team at a time. But extra large groups tended to split into smaller ones. One sprayer leading a 6-member group said he used to be in a group that grew to 13 when he decided to break off because his share of fees was decreasing.

Sprayer groups could be found almost anywhere in the irrigated area. The highest concentration found was in Bang Ngarm Subdistrict in Sriprachan. In Sriprachan, there were at least a few places with as many as 50 contract sprayers living in the same village. Sprayer groups were also found in the rainfed area, where hand-pump or manual sprayers were used. Lower rice yields and thus lower income accounted for the use of these cheaper sprayers.[8)] One group in Muang District of Suphanburi worked with their high-pressure hydraulic pump sprayer on both rice and sugarcane.

Sprayer Group Dynamics

As the rice cropping period advanced and work switched from herbicides to insecticides, group members became freer to take individual contracts. At the beginning of each rice cropping period, however, strict rules had to be followed. The group leader, or sometimes a "secretary," handled all contracting and scheduling. Members could make only tentative commitments on their own, until consulting the leader. Otherwise, if there was a scheduling conflict, they would be held individually responsible for their commitment, with no help from the rest of the group.

In general, sprayer groups took assignments from people in the village or nearby, or sometimes farther away but within commuting distance by motorcycle. Most groups had their own, higher-priority "regulars." If there was more than one group in a village, each would work within a relatively well-defined geographical area and circle of customers. Work boundaries were also partly defined by the type of crop (rice vs. others, etc.). Most contract sprayers said they would never approach other people's customers, but if someone else's customers came to them, they could take the contract, and price-cutting was also not unheard of.

———————————————————

8) Average household income in the rainfed area was only about one fourth that in the irrigated area [interviews, and Thailand, Department of Agricultural Extension 1989].

All groups reportedly shared earnings equally. Each member was responsible for all his expenses, including his mistblower and the fuel for it. There was no welfare provision from the group or among members for injury or pesticide poisoning during work. Any assistance among members was strictly personal.

Income and Fees

In addition to labor, field owners who hired contract sprayers also benefited from avoiding some health risks. Did the fees and conditions of contract arrangement reflect the health risks the contract sprayers were facing?

All interviewees cited cash income as the main reason for becoming contract sprayers—more than other agricultural manual labor (except sometimes when working for relatives). In 1991–92, general agricultural labor in the irrigated area earned 70 baht/day (US$2.8).[9] A few types of more difficult work earned more (*e.g.*, 200 baht/day for carrying rice after harvest from the field to the threshing ground). For contract spraying, it was quite common for a person to earn 300 baht for one half day. During peak periods, a contract sprayer could earn up to 800 baht/day. One interviewee who had been a contract sprayer for over 10 years said he would continue working, despite fear of pesticides, because "the money is too good to walk away from" and "when work was plenty, I actually earned more than 10,000 baht/month." However, not everyone was eager for this reason. Some felt they had little choice, because of unavoidable cash needs (*e.g.*, because of debts).

Most contract sprayers earned a similar, long-lasting set of fees for the same crop and conditions. Most fees were based on land area (per *rai*[10]), adjustable to specific situations. There were exceptions. Sometimes fees were paid per container of pesticide solution, or per day, and relatives usually paid less. Specific rates were said to depend on the following particular conditions:

Materials and Equipment. The fees differed depending on whether the field owner or the contractor provided the spraying machine and the fuel. For rice, the labor-alone fee was generally 10–15 baht/*rai* (US$2.5–3.75/ha). When the sprayer owned the mistblower, a general rule was to add 5 baht/*rai* for fuel and 5 baht/*rai* for "depreciation," so the full fee became 20–25 baht/*rai*. In all cases, pesticides were provided by the field owner.

Condition of Rice Plants and Fields. Fees were less for shorter plants (short varieties, and young plants). Tall plants that must be pushed apart during spraying were dangerous for several reasons: higher mist fallback, and sharp leaves a danger to the face and eyes, or a cut on the skin that could lead to serious injury from mist and spill. Field owners could lead the way and open the path, or else pay sprayers a higher fee. As a rule, before the pani-

9）Conversion rates at 20 baht/US$before 1990 and 25 baht/US$1990–96.
10）One *rai* is 0.16 hectare (6.25 *rai*/ha.).

cle initiation stage, the fee was 20 baht/*rai* because rice plants were "short." After that, the fee was 25 baht/*rai* (or sometimes up to 30 baht/*rai* for muddy fields or fields with standing water).

Markets and Natural Events. Interviewees cited both the high price of rice and the brown planthopper epidemic in 1989–90 as contributing to higher fees at that time. All interviewees said income in 1990 was very good, attracting a large number of new sprayers.

Other Factors. If the field owner made the pesticide solution, the fee was lowered slightly, by about 2–3 baht/*rai*. But usually the sprayers mixed the solutions. Fees might also be affected by the type of pesticide used, herbicide or insecticide, or a higher fee charged for pesticides considered more dangerous. Also, teams using manual sprayers charged less.

In the rainfed area, treatment for insect control was usually not necessary, because the traditional varieties used had high resistance against insects, and only one rice crop could be planted a year, so annual fallowing inhibited insect survival and multiplication. In the rainfed area, contract sprayers used lever-operated knapsack sprayers or slide-pump sprayers for weed control and some reportedly received only 50 baht/day.

In sum, health risks were not reflected in any of the major conditions mentioned. Even factors having direct health implications such as field conditions and the responsibility in making the solution warranted only minor differences, and the sprayers almost always had to mix the solution anyway. Mentioning that the type and the strength of pesticide *might* affect the fees reflects contractor awareness of risk, but no one said these factors actually *did* affect the fees. As will be further seen below and discussed in the conclusion, although the overall fees earned were significantly higher than for other forms of agricultural labor, it is nevertheless not likely they reflected true health costs to the contract pesticide sprayers.

Pesticide Activities

There are two principal types of activities that contract sprayers undertake that most involve contact with pesticides, and thus have health risk implications: measuring/mixing the pesticide formulas, and the spraying itself.

Measuring and Mixing

Field owners provided the pesticides and usually had the final say in determining the mixing formulas. The contract sprayers themselves were then usually responsible for the actual mixing. Many individual sprayers worked with their wives, who almost never operated the sprayers ("too dangerous for women"), but were responsible for mixing and refilling.

For herbicides, most contract groups said they followed the mixing instructions on the container label. But some field owners prepared more herbicide than needed and insisted it be all used up. Most rice field owners wanted insecticide solutions made extra strong and all used up. They believed that the unused portion would not maintain quality in storage and,

more importantly, they wanted a fast and effective result from the treatment. In general, field owners wanted insecticide to be 2–4 times as strong as prescribed in the manufacturer's directions.

But many contract sprayers themselves also believed insecticide solutions must be stronger than prescribed. One said he routinely mixed the solution stronger than what the field owner told him. If he was told to add 40 cc of concentrate to an amount of water, he would add 50, "to make sure the insects will be killed." Another said that if the label prescribed 1,000 cc of concentrate for 20 *rai* of land, he would use it all up on only 5 *rai*. Another said "I just check the label, whatever it says I halve the amount of water and double the amount of concentrate." Both these last two examples would be four times as strong as recommended by the manufacturer.

The usual practice for team spraying was to mix the pesticide solution in a large drum or other large container and then scoop it out equally into the individual spraying containers. When all individual containers were empty, they would be refilled at the same time. Less was spilled when the entire container of concentrate could be dumped into the mixing container. However, often the concentrate was instead poured out a little at a time, such as when the concentrate container was too large, when a sprayer worked alone using a small mixing bucket, or when a bottle was divided among team members, etc. In situations like these, the concentrate had to be measured out, usually using whatever was handy, the pesticide bottle lid, a plastic cup, or an empty sardine can. To stir the solution various objects were used, including wooden sticks, the spraying hose, etc.

In general, the risk of physical contact with pesticides was high during mixing, from spillage while measuring and pouring the concentrate into the mixing container, and while transferring the solution from the mixing container into the spraying containers. In addition to spillage, the high volatility of the pesticide concentrate posed an added risk for poisoning through inhalation while pouring and measuring.

Rice Field Spraying

According to interviewees, when spraying in teams, the width of the path followed by each team member was about 2–3 *waa* (4–6 meters) for herbicide spraying and about 5 *waa* (10 meters) for insecticide spraying. The teams walked faster when spraying insecticides than for herbicides. They would follow the wind direction as much as possible, sometimes crossing the wind. When the wind was strong, they would spray only in one direction and not while walking back, although some said they would also spray behind them while walking back into the wind. A few said observing the wind direction was necessary only for insecticide spraying, since for herbicide treatment the sprayer nozzle was aimed at the ground.

In small teams (*e.g.*, 2 persons), team members walked parallel to the paddy dikes and just generally tried to avoid each other, but in larger teams (*e.g.*, 4 persons) they would form a line and walk side by side, or in a "staircase" pattern (waiting until the next person was far enough ahead before beginning to walk). They said the staircase pattern better allowed

them to avoid the mist, especially if crossing the wind.

It was clear from description and observation that it was virtually impossible to consistently avoid contact with pesticide mist when operating with multiple mistblowers in this manner.

Crops Other than Rice

Rice lands were the largest areas sprayed by the contract sprayers, and were where most contract sprayers worked. But some sprayers did work on other crops: sugarcane, corn, water chestnut, vegetables and a few others. It would be too space-consuming here to describe pesticide application activities on all these crops, but they do have some distinctive features.

Most importantly, pesticide application on some of these non-rice crops was found to be more *intensive* than on rice, especially on vegetables and water chestnut. Treatment of vegetables was very frequent and thorough, right up to the day before harvest. As one interviewee explained, "people won't buy them if they don't look real nice."

For non-rice crops, field owners usually supplied everything needed except the labor, which tended to further reduce the bargaining power of the people hired to do the spraying, concerning what types of pesticides and machines and how to use them. Fees tended to be higher than for regular agricultural labor, but probably not enough to reflect the additional risks.

Another alarming finding was that young children were being employed to plant corn seeds coated with the highly hazardous insecticide Furadan (carbofuran)[11] with their bare hands ("the children are actually faster . . . more agile . . . and it frees the adults to do the heavier work").

Hazard Awareness and Safety Measures Taken

Contract sprayers were in much more frequent contact with chemical pesticides than the average farmer. As professional sprayers, did they have a superior understanding of health hazards and safety measures, and what did they do to protect themselves?

Most contract sprayers were able to answer right away when asked to name the pesticides they most frequently used, even though pesticides were almost always selected by the field owners. Of the 80 trade names mentioned, 75 were able to be identified by their "common" generic names (Table 2).

Although this study did not use sample survey methodology, it may be reasonable to assume the relative number of times a product was mentioned suggests a rough approxima-

11) Trade names are capitalized and followed by common (generic) names of their active ingredients in parentheses ("ISO or national standards . . ." [ARSAP 1991: 11]).

Table 2　Frequently Used Pesticides Cited by Contract Sprayers, by WHO Hazard Class

Insecticides	Class Ia—Extremely Hazardous: Folidol (methyl-parathion); Melin 24, Nockphos (mevinphos); Agto-B (epn + monocrotophos) Class Ib—Highly Hazardous: Azodrin, Challenger, Dollar, J.Cron, Jagur, Mono, Monocrotophos, Monocron, Nuvacron, Pan Dar, Starwar (monocrotophos); Medic, Methamidophos, Tamaron (methamidophos); Curaterr, Furadan (carbofuran); Biteen, Carbicron (dicrotophos); Eco-VP (dichlorvos); Hostathion (triazophos); Lannate (methomyl) Class II—Moderately Hazardous: Alamon (heptachlor); Curacron-A (profenofos); Egodan, Thiodan 35 (endosulfan); Fastac D (alphacypermethrin + fenobucarb); Ceasar (fenobucarb); Lentrek (chlorpyrifos); Mipcin (isoprocarb); Natsir (dimethoate); Padan (cartap hydrochloride); Padan-mipcin (cartap hydrochloride + isoprocarb); Posse (carbosulfan); Sevin (carbaryl); Simubas (fenitrothion + fenobucarb); Victor (cypermethrin); Zolone (phosalone) Class III—Slightly Hazardous: Sinol (dicofol) Table 5—Unlikely Acute Hazard in Normal Use: Applaud (buprofezin)
Herbicides	Class II—Moderately Hazardous: Gramoxone (paraquat dichloride); Comet, Hecto, Hedonal-D (2-4,D); Saturn (2-4,D + thiobencarb); Saturnil, Naguard(propanil + thiobencarb); Ordram-plus (molinate + propanil); Avironsan (demethametryn + piperophos); Challenge, Chopin (butachlor + propanil) Class III—Slightly Hazardous: Dulachlor (alachlor); Propanil (propanil) Table 5—Unlikely Acute Hazard in Normal Use: Atrazine (atrazine); Butachlor (butachlor); Sofit (pretilachlor); Eagle, Sun-up (glyphosate); Facet (quinclorac); Londax (bensulfuron-methyl)
Fungicides	Class III—Slightly Hazardous: Kitazin (iprobenfos); Terrazole (etridiazole); Terraclor SuperX (etridiazole + quintozene) Table 5—Unlikely Acute Hazard in Normal Use: Bawesan (cabendazim); Benlate (benomyl); Dithane M22 (maneb); Dithane M45 (mancozeb); Elosal (sulphur); Lonacol 80 WP (zineb)
Others	Molluscicide Mesurol (mercaptodimethur—WHO Class II); Acaricide Eco-T (tetradifon—WHO Class Table 5); Crabtocide Sumithion (fenitrothion—WHO Class II)

Sources: Field interviews of contract sprayers, Suphanburi, Thailand, 1991, 1992. Hazard classification from Thailand, Agricultural Regulatory Division [1994] and ARSAP [1991].

Notes: 1) Local trade names capitalized, common (generic) names in parenthesis.

2) Heptachlor was banned in 1988, mevinphos and monocrotophos banned in 2000, methamidophos in 2003 [Thailand, Ministry of Industry 1995, 2000a, 2000b, 2001, 2003].

3) WHO classification based on LD_{50}, defined as a single dose which kills 50% of test animals, expressed in (oral, dermal; solid, liquid) mg per kg animal body weight. The smaller the LD_{50} value, the more toxic. A Class Ia (“extremely hazardous”) pesticide has oral solid LD_{50} of 5mg/kg (liquid 20mg/kg) or less; Class Ib is 5–50mg/kg (liquid 20–200mg/kg) [ARSAP 1991: 497; Dudani and Sengupta 1991: 43].

tion of fairly widespread frequencies of usage of that pesticide in the study areas. Out of 106 times that insecticides were named, nearly three quarters of the time those that could be identified fell into the World Health Organization Hazard Class Ib—"highly hazardous." Leading the list were monocrotophos (mentioned 43 times) and carbofuran (15 times). WHO Class Ia, "extremely hazardous," was also represented (11 times).

Interviewees were certainly aware of the general risk of working with pesticides. They knew of some sprayers who quit because of ill health due to long exposure and some had even died. Most of them said they were "afraid" of pesticides because "they are very dangerous." One said his relatives and friends referred to his occupation as being "hired to die."

Yet more than a few seemed totally unafraid, or just ignored their fears. "They can't hurt me, I've been doing this for so many years now," and "I always work with my bare hands, nothing has ever happened." One 40-year-old man said he picked up Furadan (carbofuran—Class Ib) with his bare hands, "been doing that for more than 10 years now . . . never got sick from it . . . ."

As shown above, many of the pesticides the contract sprayers used are dangerous—potentially deadly even in surprisingly small amounts, *e.g.,* for WHO Class Ia "a splash in the eye," for Class Ib "a teaspoon" [Dudani and Sengupta 1991: 43; also see notes to Table 2]. Equal harm can result from somewhat larger doses through skin absorption anywhere on the body, especially if not immediately washed off. Repeated exposures can also cause harm, including death, through successive accumulation in the body.[12] Different pesticides require different degrees of protective measures, but in general, dangerous pesticides need very careful handling and use of protective gear, such as special masks, protective clothing, rubber gloves, rubber boots, etc. If this is not possible, e.g., due to tropical working conditions, dangerous pesticides should not be used [GIFAP 1983; ARSAP 1991: 29].

How did the contract sprayers dress during spraying? Most wore a long-sleeve shirt over a crew-neck T-shirt and long trousers, but others wore no shirt underneath. Contractors in the rainfed area wore only T-shirts, and no hats or masks. Most sprayers wore some types of covering on their head, often covering part of their face as well: a hood like a ski mask, bandana over the mouth and nose, or a cheap disposable paper mask. Very few wore the type of mask recommended by agricultural extension officials. No one wore shoes or boots during rice field spraying. Most wore rubber slippers (flip-flops) while walking on the paddy dikes but took them off before working in the rice field because "the mud is really sticky, it pulls any footwear right off your feet." Hardly anyone wore gloves during mixing or spraying ("gloves are hot and cumbersome"). When working with "tall" rice, people did wear work gloves and socks, or plastic bags on their hands and their feet, and some also wore spectacles to protect their eyes. Sugarcane sprayers sometimes wore socks, and

12) Repeated or long-term exposure to organophosphates and carbamates causes persistent damage to the central nervous system, among other physical and neuropsychiatric effects [Wesseling *et al*. 2002], loss of peripheral nerve function [Stokes *et al*. 1995], and contributes to morbidity in severe cases [Minton *et al*. 1988].

one field owner said he also provided them with rubber boots.

The vast majority of sprayers had one particular set of clothing that they reserved specifically for pesticide spraying. This set was washed upon finishing spraying each day and worn again, sometimes before being completely dry, for the following session. Some skipped daily washing when they had to work every day, but “I wash them every two to three days.”

The practices described and observed suggest a casualness toward skin exposure and a misunderstanding of how dangerous it is. Two sprayers claimed to have stirred pesticide solution with their bare hand. Sprayers tended to leave the container strapped to their backs while their colleagues or wives refilled it. Pesticide frequently spilled or leaked onto the sprayers’ backs, but most people continued spraying until the container was empty, or until the entire task was finished, before breaking to rinse off. However, there were usually no nearby sources of clean water out in the fields. Thus not washing off until later may not have been by choice.

A few sprayers had some say about what pesticides they would not work with. One group refused to work with the fungicide Hinosan (edifenphos—WHO Class Ib, “highly hazardous”). One interviewee said he would never agree to handle Methamidophos (also WHO Class Ib), because “it smells really bad—that means it is very strong and dangerous.” But ability to bargain was limited. A few field owners consulted the sprayers, but most interviewees said they simply accepted whatever pesticide the field owner chose, even if they disliked it. As one said, “if word gets around that you are choosy about which pesticides you use, people won’t hire you.”

While most sprayers seemed to know the pesticides they most frequently worked with, one group of sprayers said that sometimes they were not told the name and there was no label on the container. One key informant said some field owners did not want anybody to know that they were using banned pesticides. But others pointed out that sometimes “the label comes off so easily . . . even when you spill just a little liquid on it.” Whatever the reason, without knowing the name, the sprayers would not have the information critical for medical treatment in case of poisoning.

Most interviewees were generally aware of safety recommendations but often had their own reasons for not complying. Many believed that insecticides need to be mixed much stronger than prescribed. Of course this is dangerous, but it would also be understandable how they came to believe this if the pesticides they used were sometimes of substandard quality. This is actually rather likely to have been the case. Regular tests of pesticides being used in Thailand frequently showed major deterioration of active ingredients [Grandstaff 1992: 50–51; Chatpong 2001: 33–37]. Increasing the concentration of insecticides, or using a “cocktail” to kill more than one type of pest [Grandstaff 1992: 16], meant the job would not have to be repeated and thus increase costs to farmers. Repeated walking in rice paddies that have been direct-seeded, rather than transplanted, also damages the rice, because there are no “rows” to walk in between. Stomping around in rubber boots would also increase

damage to the rice, for the same reason.

All sprayers seemed to know that the longer they worked with pesticides, the more dangerous it was, and hoped to quit before permanent health damage. In response to the question "how long a healthy person in his 20s, doing spraying almost every day, should work as a contract sprayer," more than half said "no more than 5 years." But most also said they intended to continue until they "really cannot do it anymore." Nearly a third had already been working at least 5 years, and nearly a fifth for 10 years or longer (Table 1).

In short, the contract sprayers did not adequately protect themselves. They were probably better informed than the average farmer, but also seemed to have some serious misunderstandings (*e.g.,* concerning dermal contact and longer-term, accumulating poisoning). However, local conditions seemingly beyond their control also played an important part.

Health Problems Related to Pesticide Spraying

A large majority of contract sprayers (32 out of 39) said they had experienced one or more episodes of unconsciousness— "knocked out by the drug" (Table 1). Some interviewees had suffered as many as three such incidents and still remained in the profession. In some groups, all members had suffered "*knock*" at least once. Many others suffered less severe symptoms, short of passing out, but enough to stop them working. Common symptoms included numbness throughout the body, vomiting, diarrhea, trembling, muscle spasm, blury vision and "confusion" (*ngong*). In one group, all members had experienced dizziness and nausea but none had ever fallen unconscious.

Several contract sprayers said they had suffered poisoning from a herbicide called Sofit (pretilachlor).[13] Most who first claimed never to have experienced pesticide poisoning, upon probing by the researchers, said they did experience exhaustion and light-headedness during spraying but "never fainted." Many said they had a history of repeated serious poisoning and were treated with intravenous infusion of saline solution (saline drip).[14] One interviewee who quit contract spraying three years prior to the interview said he experienced "*knock ya*" only twice, but the second time was so severe that he was hospitalized for one whole year. Major symptoms he remembered included numbness of the body and inability to move. The doctor told him that he had accumulated exposure and "you are lucky you didn't die."

Most contract sprayers feeling the onset of symptoms continued working and stopped only if symptoms became severe. This was a matter of individual subjective judgment. One

13) "Unlikely to present acute hazard in normal use" [ARSAP 1991: 448]. Perhaps they used a stronger-than-normal mixture, or failed to observe "normal" handling procedures.

14) According to medical professionals, intravenous saline solution helps purge a small portion of toxin, but total cessation of exposure is required for a long period (weeks, months) for the body to get rid of the remainder.

interviewee said he would stop and go home when he felt light-headed, tired, irritable, perspired unusually heavily, and had blurry vision. If the situation did not improve after resting at home, he would go get a saline drip treatment at the local public health station and go back to work when the symptoms improved. If he felt the injury was serious, he would take the label from the pesticide container along when seeking treatment.

Some pesticide poisoning victims treated with saline drip stopped working for only a few days. One interviewee who was receiving saline drip at home at the time of the interview told the researchers that he intended to go back to work the following day because "I promised my customer so I must try." In any event, he intended to rest for no more than two days.

There is an additional factor which might have health implications for contract sprayers. About three quarters of all interviewees regularly took medicine "to prevent pesticide poisoning" (Table 1). Some took drugs after spraying "to purge the poison." They also drank energizing beverages for additional strength. Examples included Krathing Daeng ("red gaur"), M-100, M-150, etc.[15] One sprayer regularly drank Krathing Daeng with a painkiller (Tra Khrok Bod Ya), the active ingredients of the latter being 450 mg aspirin and 30 mg caffeine anhydrous. He explained that the drug made him sweat during spraying which helped push the poison out of his body while also curing his muscle pains. Other drugs commonly used by contract sprayers also consisted of various doses of aspirin: Buadhai (650 mg per envelope), Thamjai (650 mg per packet), and ANT (325 mg per tablet, 4 tablets per envelope).

Besides painkillers, other drugs taken by contract sprayers included many antiallergics and antacids, also Atropine (atropine sulfate), Antrenyl (oxyphenonium bromide) and Dendox (doxylamine succinate, dicycloverine and pyridoxine HCI). Some took a combination three-tablet set sold by a local drugstore, later identified as one analgesic (paracetamol) and two types of antidepressant.

The contract sprayers took drugs of their choice either before spraying or when symptoms of poisoning were felt. One interviewee who bought an antiallergic drug at 2 baht per pill from a drugstore took one tablet right after each spraying session and would thus be taking more than one tablet on days he had to work at more than one site. Another used to buy an antiallergic drug at five tablets for 1 baht, to be taken one daily. He took a pill before the meal prior to spraying, as a preventive measure, but skipped the pill if he did not eat any food before spraying. But he stopped using the drug because "it made me sleepy and sluggish."

It is not known how widespread the practice of taking antiallergic drugs was, but medical opinion is that taking antiallergics before pesticide spraying is very dangerous. The drug apparently slows down the symptoms of pesticide exposure, increasing the danger of acute poisoning. By the time the person begins to feel the impact, the body could have already absorbed enough toxin to cause serious injury. Also, taking drugs to induce sweating does not help purge the poison. It does the opposite—it increases skin absorption

15）All the capitalized terms in this paragraph are local trade names.

[GIFAP 1983: 39].

In addition to oral drugs, members in this same team also relied on injection "to purge the poison." All members received injection once a month at a private clinic in the capital town of the province, to treat symptoms of pain in the back of the head and muscle aches. None of them knew what the injection contained. Another said he took "poison-purging medicine" given to him by his sister who obtained it from a hospital in Bangkok. In addition, he took a tablet of an unknown drug once a day, after a meal, to induce perspiration in order to "push" the poison out of his body. The majority of contract sprayers also drank carbonated beverages to induce burping, believing it brings up toxic fumes entering the throat during spraying.

One group leader said that during a very busy work period, such as during the brown planthopper epidemic, all in his group went to the local health station for saline drip treatment at the end of each rice cropping period. Some also resorted to various types of herbal medicine. One who had suffered two episodes of acute poisoning in three years said he also went to a private clinic in town regularly to have his blood tested to keep track of the pesticide impact. His most recent test showed that "everything is fine, there's nothing wrong with me." However, it is very unlikely that whatever test he took had actually specifically tested for pesticide poisoning.[16)]

Conclusion and Recommendations

This study found that almost all pesticide contract sprayers encountered in Suphanburi Province experienced health problems of various forms and degrees from pesticide exposure. Most had experienced highly noticeable, severe symptoms, including unconsciousness. Most were aware that pesticides are dangerous, some especially so, and took steps to try to protect themselves, to treat their injuries and monitor their health. Most hoped to quit contract spraying before incurring permanent damage to their health, and some did quit. But most continued working, often going back to work just a short time after apparently serious poisoning.

The results of this study suggest that several different, interacting factors contributed to the inadequate degree of protection and treatment found (and there may be others as well, not identified in this case study): lack of awareness, lack of bargaining power, difficult local conditions, use of highly hazardous pesticides, and inadequate monitoring and treatment capability.

Awareness. The study indicated that contract sprayers took inadequate protection and treatment measures in part because they did not understand enough about the less notice-

16) Confirmed by related research involving medical doctors in the same area at this time.

able accumulative effects. Almost every measure they took, for both prevention and treatment, seemed focused only on relieving (or masking) the immediate, most noticeable symptoms. They wrongly believed that when these most noticeable symptoms went away, they were cured and it was safe to continue working.

Bargaining Power. All contract sprayers interviewed consistently confirmed that money was the main factor attracting them to this profession—better earnings than for other agricultural labor. But these earnings were not gained without cost, especially cost to health. Like the labor markets in many developing countries, the contract sprayers operated in a "buyer's market." This was demonstrated by their concerns and accommodations. For example, they strongly feared that field owners would not hire them if they did not spray thoroughly enough or refused to work with particular pesticides. In this kind of situation, it is likely that the fees they charged did not reflect the full cost, and not just because of inadequate awareness of health hazard. A carefully designed extended benefit-cost analysis of engaging in contract spraying could be done to evaluate this. The results could have important policy implications.

Local Conditions. Local weather and biophysical conditions in the paddy fields were also cited by the sprayers themselves, and noticed by observers, as inhibiting the use of better prevention and safety measures. It is a mistake to assume that simple ignorance was the principal reason for not adopting better safety measures. Official recommendations for pesticide use *had* reached the study areas and many contract sprayers were aware of them, but had their own reasons for not following them. Medical and agricultural professionals need to work closely together, and interactively with the sprayers, to redesign their prevention and safety programs, to make them more suitable to local conditions faced by sprayers in their work. (As a very brief example: what and how to mix and not mix in a "cocktail," not just: "Don't mix.")

Dangerous Chemicals. The Thai government has not been sitting idly by since the fieldwork for this study was done in the early 1990s. The Hazardous Substances Act was passed in 1992. By the mid-1990s pesticide container labels were required to have color codes for the degree of hazard and pictograms illustrating the types of safety measures needed [Thailand, Ministry of Agriculture 1995]. In 2000–03, several of the more commonly used chemicals mentioned in this report were banned from being imported and used in Thailand [see notes to Table 2].

Despite government efforts, serious health problems still remain in agropesticide usage, in Thailand and elsewhere and the Thai government is apparently still largely unaware of the extent of the agropesticide poisoning problem.[17] There are many very dangerous pesticides that still remain that should probably be banned, or alternatively, those who are allowed to use them should logically be required to be trained and licensed.[18]

The issue of varying quality of pesticide products on the market (deterioration of active ingredients, etc.), while not the subject of this research, does seem to be related to the common practice of mixing pesticide solutions at higher than recommended strengths. The Thai government is aware of this standards problem, and has been taking steps to try to improve the situation [*e.g.,* Chatpong 1997; 2001]. The issue seems to be complex, so more effort and policy priority are probably needed.

Monitoring and Treatment. The contract sprayers profiled in this case study are obviously one category of people at high risk for pesticide poisoning, and there may be other types of high-risk people as well. It should be evident that focused inquiry is needed throughout the entire country to pinpoint those most at risk, including children. Priority must be given to *operational* strategy, *e.g.*, rapid use of intermediary or surrogate sources of information. It could be thought of as jump-starting a rapid response to a deadly epidemic, because, in all likelihood, that is what it is.

Wherever those most at risk are found in concentrated residence patterns, such as found in this study (or as in recently described "widow villages" of chili pepper sprayers in Kanchanaburi [Praphanwong 2004]), action programs will be facilitated. Government health clinics in such villages can be targeted for increased diagnostic and treatment capability. People interviewed in this study clearly very much wanted this capability, and without it some resorted to private clinics offering "blood tests." Mobile medical units can also be dispatched to help fill the gaps. A portable machine can test for an enzyme called cholinesterase (ChE) level in the blood.[19] Although this tests degree of exposure only for organophosphates and carbamates, these two groups account for a large majority of all insecticides used in Thailand.[20]

The agropesticide poisoning problem has for far too long been stranded in a sort of no-man's-land, in between academic fields and in between the Ministry of Agriculture and the Ministry of Public Health. A more workable arrangement has to be found, and surely the Ministry of Public Health will have to be involved in very major way. Only the medical profession has the necessary level of credibility on a major health issue like this. After the ChE

17) "Almost 100% of farmers are affected from using pesticides" and "for sure, the government does not have any statistics on this" (because most don't seek treatment) [Srinivet n.d.(c.2000): 3]. Existing statistics are also misleading: *e.g.*, showing more "intentional" than occupational pesticide poisonings [Thailand, Ministry of Public Health, n.d. (*c.* 2001)].

18) For example, WHO Class Ia insecticides still account for 18% of all insecticides imported, 39% for both Ia and Ib [calculated from Thailand, Agricultural Regulatory Division 2003].

19) ChE is an enzyme in the blood which affects nerve impulse transmission (to many organs of the body, including the heart). It's level and functioning is inhibited by certain types of chemicals in organophosphate and carbamate groups [Thailand, Division of Occupational Health 1990: 1].

20) Organophosphate and carbamate groups accounted for 76–83% of the total tonnage of all insecticides imported to Thailand between 1985 and 1989, 82% in 1993, and 91% in 2003[Thailand, Agricultural Regulatory Division 1985–90, 1993, 2003] .

test, for example, individual sprayers at most immediate risk could be told by a doctor or other authoritative medical professional, “You need to quit spraying, right now, for at least three months, or you might die.” This was tried in Suphanburi, and it worked.

References

Agricultural Requisites Scheme for Asia and the Pacific (ARSAP). 1991. *ARSAP/CIRAD Regional Agro-Pesticide Index* Volume 1*, Asia*. Bangkok: Economic and Social Commission for Asia and the Pacific (ESCAP).

Anonymous [Editorial]. 2003. Policy and Master Plan on Pesticide Usage. *Entomology and Zoology Gazette* 25(1): 1–2. (in Thai)

Chatpong, Krisna. 1997. Study on the Degradation of Pesticide Products. *Toxic Substances News and Reports* 24(3): 101–115. (in Thai)

————. 2001. Quality of Pesticide Products. *Toxic Substances News and Report* 38(3): 33–37. (in Thai)

Dudani, A.T.; and Sengupta, Sanjay. 1991. *Status of Banned and Bannable Pesticides*. New Delhi, India: Voluntary Health Association of India.

Grandstaff, Somluckrat. 1992. *Pesticide Policy in Thailand*. A final report submitted to the FAO Regional IPC Programme, Manila, Philippines. Bangkok: Thailand Development Research Institute.

————. 1996. A Pesticide Poisoning Incidence Study. In *Final Report: Proposed Program for Activities in the Area of Issues Related to Chemical Pesticides for Thailand Development Research Institute (TDRI)*.

Grandstaff, Somluckrat W.; and Grandstaff, Terry B. 1987. Semi-structured Interviewing by Multidisciplinary Teams in RRA. In *Proceedings of the 1985 International Conference on Rapid Rural Appraisal*, *Khon Kaen University*, pp.129–143. Khon Kaen, Thailand: Rural Systems Research and Farming Systems Research Projects.

Grandstaff, Terry B.; and Messerschmidt, Donald A. 1995. *A Manager’s Guide to the Use of Rapid Rural Appraisal*. Bangkok: Food and Agriculture Organization of the United Nations.

Groupement International des Associations Nationales de Fabricants de Produits Agrochimiques (GIFAP). 1983. *Guidelines for the Safe and Effective Use of Pesticides*. Bruxelles: GIFAP.

Minton, N.A.; and Murray, V.S. 1988. A Review of Organophosphate Poinsoning. *Medical Toxicology and Adverse Drug Experience* 3(5): 350–375.

Praphanwong, Suchada. 2004. Invading “the Land of the Dead”: Confirming the Cause of Death in “Widow Villages”. *Matichon Daily*, May 25, pp. 33–34. (in Thai)

Ratanasathien, Paisan. 1995. Motorized Knapsack Mistblowers. *Entomology and Zoology Gazette* 17(3): 172–280.

Srinivet, Sukda. n.d. [c. 2000]. What Will Happen if Farmers Keep Insisting on Using Chemical Pesticides? http://www.doae.go.th/report/sukda/if.html (in Thai)

Srisupan, Waraporn. 1993. A Study of the Contract Pesticide Spraying Groups, Suphanburi Province. Bangkok: Thailand Development Research Institute. (draft, in Thai)

Stokes, L.; Stark, A.; Marshall, E.; and Narang, A. 1995. Neurotoxicity Among Pesticide Applicators Exposed to Organophosphates. *Occuptional and Environmental Medicine* 52(10): 648–653.

Sutherland, J.A. 1980. *Mistblowers*. College House, London: Centre for Overseas Pest Research.

Thailand. 1992. *Hazardous Substances Act B.E. 2535*. (in Thai)

Thailand, Agricultural Regulatory Division. 1985–90. *Pesticide Statistics* (*Quantity of Importation, Formulation, Supply and Use*). Bangkok: Agricultural Regulatory Division, Department of Agriculture. (in Thai)

————. 1993. *Statistics of Imported Pesticides*. Bangkok: Agricultural Regulatory Division, Department of Agriculture. (in Thai)

————. 1994. *Registration of Agricultural Toxic Substances in Thailand*. Bangkok: Agricultural

Regulatory Division, Department of Agriculture.

————. 2003. Import Data on Hazardous Substances, 2003. Bangkok: Agricultural Regulatory Division, Department of Agriculture. (mimeograph)

Thailand, Department of Agricultural Extension. *Guidelines for Agricultural Development, by Subdistrict, 1989*. Suphanburi: Provincial Agricultural Extension Office. (in Thai)

Thailand, Division of Occupational Health. 1990. *A Manual for the Testing of Cholinesterase by Using a Special Testing Paper*. Bangkok: Department of Public Health. (in Thai)

Thailand, Epidemiology Division. Various issues 1980–94, 1998. *Annual Epidemiological Surveillance Report*. Bangkok: Ministry of Public Health.

Thailand, Ministry of Agriculture. 1995. Notice of the Ministry of Agriculture and Cooperatives on the Subject of Label and Toxic Levels of Hazardous Substances under the Authority and Responsibility of the Department of Agriculture. *Hazardous Substances Act B.E. 2535*. (in Thai)

Thailand, Ministry of Industry. 1995, 2000a, 2000b, 2001, 2003. List of Hazardous Substances Banned for Use in Thailand Issued under the 1992 Hazardous Substances Act. http://www. doa. go. th/other/toxic_2/prakad_1.html (in Thai)

Thailand, Ministry of Public Health. n.d. [c. 2001]. Thailand's Country Profile on Pesticide Poisonings. http://www.fda.moph.go.th/ipcs/Output/Manu_link03/link3.1.html

Thailand, National Statistical Office (NSO). 1978, 1983, 1993a. *Agricultural Census*. Bangkok: Office of the Prime Minister.

————. 1993b. *Provincial Statistics Report, Suphanburi*. Bangkok: Office of the Prime Minister.

————. 1996. *Statistical Yearbook*. No. 43. Bangkok: Office of the Prime Minister.

————. 2003. Advance Report of the Agricultural Census. http://www. nso.go.th/eng/agriculture/agr_census2003.htm

Wangvipula, Ranjana. 2004. Pesticides Remain Weapon of Choice. *Bangkok Post*, March 8.

Wesseling, C.; Keifer, M.; Ahlbom, A.; McConnell, R.; Moon, J.D.; Rosenstock, L.; and Hogstedt,C. 2002. Long-term Neurobehavioral Effects of Mild Poisoning with Organophosphate and n-methyl Carbamate Pesticides among Banana Workers. *International Journal of Occupational and Environmental Health* 8(1): 27–34.

Yin, Robert K. 1994. *Case Study Research: Design and Methods*. Applied Social Research Methods Series. London: Sage Publications.