CHAPTER 1

INTRODUCTION

1.1 Problem Statement

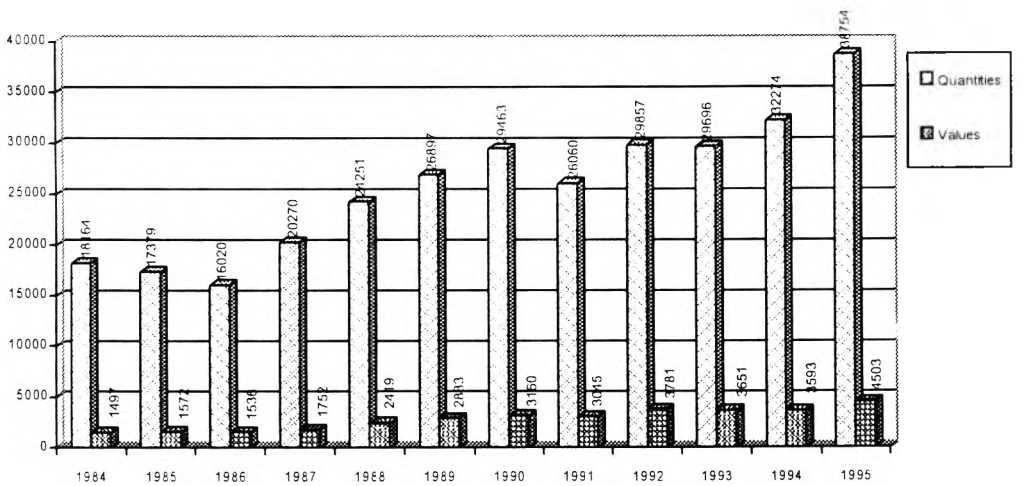
Nowadays Thailand has been encountering a rapid development, especially in agricultural area in which various toxic chemicals begin to play a greater role and are used in greater quantity. Nevertheless, carelessness and misuses of those chemicals could immensely cause both health hazards, not only to users who are farmers themselves but also to the consumers of chemically contaminated products, and subsequently environmental problems. Causal factors leading to extensive uses of pesticides are as follows:

1. To improve quality of foods.
2. To reduce production costs.
3. To control communicable diseases caused by various infectious microorganisms.
4. To protect pets and livestock.
5. To reduce manpower

Quantities and types of chemicals used for agricultural purposes greatly increased during 1984 – 1995 as shown in figure 1.1. In addition, the quantity of pesticides imported has also continuously increased. Insecticides are imported in two forms, which are

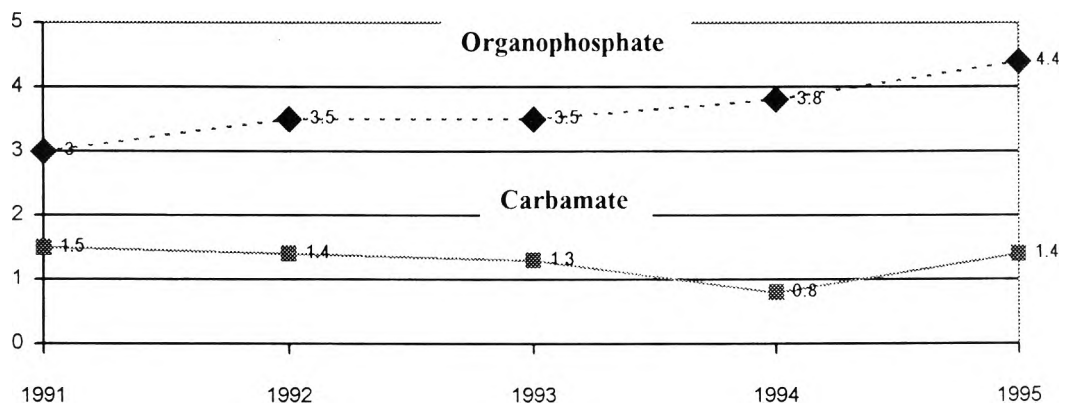
1. Concentrated chemicals, which are further diluted and mixed in Thailand.
2. Finished products, which are normally delivered in bulky packaging and are repacked in Thailand (Downrai A., 1996).

Figure 1.1 Thailand consistently imported organophosphate two times the amount of carbrmate during 1984-1995.



Source: Division of Agricultural Plant and Material Control, Department of Agriculture, Ministry of Agriculture and Cooperatives.

Figure 1.2 The quantities of Organophosphate and Carbamate insecticides imported during 1991-1995



Source: Workshop on "*Application of Test Kits for Quantitative Determination of Cholinesterase - Fieldwork*" 26-28 February 1996 at Asia Hotel, Bangkok, and Health Science Research Institute, Ministry of Public Health, Nonthaburi.

The causal factor for continuously increasing quantity of insecticides use was that the majority of farmers did not follow the instruction labeled on the insecticide container, and lack of knowledge and understanding about insecticides (Vichien, 1980). As insecticides were not used correctly, the insects then gradually developed their resistance to the effect of the insecticides (Siriwat, 1971). Farmers then needed to increase doses of those insecticides to give effective results. Presently, the number of people, whose work involved in agricultural chemical uses, was estimated to be approximately 18 million people. This problem is also considered to be a critical public health problem in Ubonratchathani Province.

Ubonratchathani Province occupies 105,608 Rais of agricultural land as vegetable farms (the Agriculture Statistic Bureau, Ministry of Agriculture and

Cooperatives, 1991). Trakanphutphon District occupies 3,181 Rais useful for vegetable farms. Farmers normally grew vegetables for domestic consumption and for distribution to the two local markets in Trakanphutphon District where the vegetables were further distributed by merchants to consumers of the nearby districts. Therefore, safety and quality of vegetables consumed among the population of Trakanphutphon District and the nearby districts largely depended on this farmer group.

The occupational health work in agriculture involves a screening program by the Bigg's Method (1958) for chemical contamination levels in blood of the farmers every year using special reactive papers to detect for Cholinesterase enzyme. This technique is commonly employed for monitoring hazardous effects of Organophosphate and Carbamate insecticides. These insecticides are inhibitors of Cholinesterase enzyme whose function is to digest Acetylcholine into an acid and Choline as in the following equation:

$$\text{Acetylcholine} \xrightarrow[\text{Enzyme}]{\textit{Cholinesterase}} \text{Acetic acid} + \text{Choline}$$

The resulting acetic acid will change the colour of Bromothymal blue indicator on the reactive test paper. The test could then indicate hazardous tendency resulted from the above insecticide groups (the Handbook for Cholinesterase Enzyme Test, Division of Occupational Health, Department of Health, Ministry of Public Health). In addition to the annual blood test, the farmers were educated with correct procedure for pesticide practices every year. Nevertheless, the test results for the area of Ban Hee,

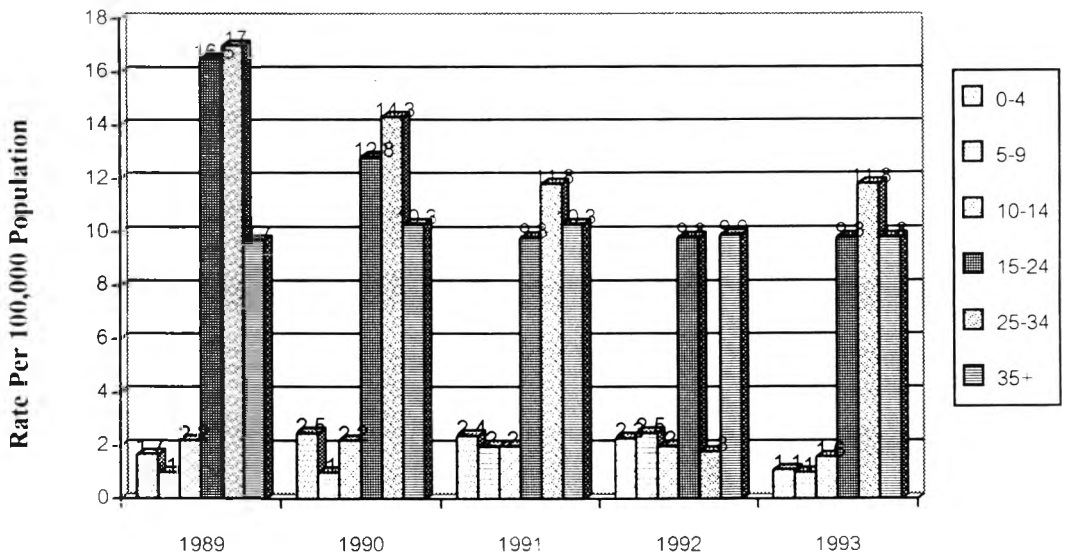
Moo 2 and Moo 3 indicated high percentages of farmers with potential risks and unsafe chemical contamination levels in their blood as shown in the following details:

1. In 1997, there were 54.33 % of the blood test results with risky and unsafe levels.
2. In 1998, there were 53.20 % of the blood test results with risky and unsafe levels.
3. In 1999, there were 52.00 % of the blood test results with risky and unsafe levels.

The standard limit is 20 % maximum (Division of Occupational Health, Department of Health).

It could be seen that the farmers' blood test results indicated alarmingly high percentages of the populations with risky and unsafe chemical contamination levels. Moreover, there was only a slight drop of the chemical level each year. The study on factors influencing pesticide practices found that knowledge, attitudes, and past training experiences affect farmers' pesticide practices (Dithisawadvate S., 1992). When considering each region separately, toxic effects manifested at highest level in the Northern region. The subsequent ranking was the Northeastern, Central, and Southern regions respectively. The age group found with the highest poisoning level was between 25-34 years old, as shown in Figure 1.3.

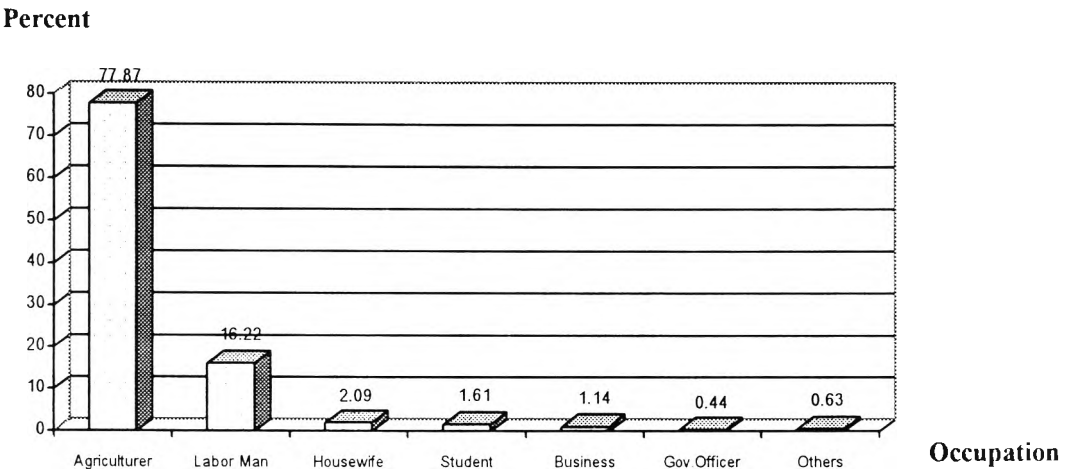
Figure 1.3 Reported cases of pesticides poisoning per 100,000 populations by age group, Thailand, 1989-1993.



Source: Workshop on "*Application of Test Kits for Quantitative Determination of Cholinesterase - Fieldwork*" 26-28 February 1996 at Asia Hotel, Bangkok, and Health Science Research Institute, Ministry of Public Health, Nonthaburi

Figure 1.4 showed proportion of various groups of occupations reported with pesticide poisoning effects. It was found that the highest percentage of pesticide poisoning was among the group of farmers with 77.87 % of the total reported cases.

Figure 1.4 Proportion (%) of pesticide poisoning by occupation, Thailand, 1993.



Source: Workshop on "*Application of Test Kits for Quantitative Determination of Cholinesterase - Fieldwork*" 26-28 February 1996 at Asia Hotel, Bangkok, and Health Science Research Institute, Ministry of Public Health, Nonthaburi

Studies on pesticide poisoning classified by pesticide group found that the pesticide group demonstrating the highest toxicity was Organophosphate. The next groups in ranking were Herbicide and Carbamate respectively (Division of Epidemiology, the Office of Permanent Secretary, Ministry of Public Health, 1984-1993).

Problems caused by misuses of pesticides can be summarised as follows:

1. Acute toxicity to the user and chronic toxicity, which could occur to the user after prolonged exposure to the chemicals.
2. Contamination of pesticide residues in agricultural products.
3. Health hazard risks to the consumers of such contaminated products.

4. Problems of environmental pollution such as soil, water, air and ecosystem cycles (the Office of the National Environment Board).

Regarding human health problems, pesticides could enter the body through 3 main ways, skin contact (71%), ingestion (11%) and inhalation (8%). Other ways account for 10%. Pesticides are normally accumulated in fat tissue layers called "Adipose tissues". These toxic substances are released into blood vessels and to other major organs producing toxic effects at later stages. This constitutes chronic toxicity and consider as carcinogens in human. (Pimsaman S., 1997).

Organophosphate pesticides have an inhibitory effect on the functions of Acetylcholinesterase enzyme in all body organs. Accumulation of Acetylcholin-esterase in large quantity will produce destructive effects or cause paralysis, especially to the central nervous system. Symptoms could begin with nausea, vomiting, scattered muscle contraction, and pain in the chest. Other possible symptoms include vomiting, diarrhoea, blurred vision, excessive secretion of saliva, and drowsiness Severe symptoms are coma, convulsion, breathing difficulty, and eventual death due to respiratory failure (Pimsaman S., 1997).

It can be seen that the effects of chemical substances are immense. Misuses of chemicals are comparable to hidden dangers that threaten life slowly as mentioned previously. The study of Dethisawadvate (1993) found that knowledge, attitudes, and past training experiences had an effect on pesticide practices. The fieldwork operation of this study involved local staff providing essential knowledge to farmers and

conducting blood tests for chemical contamination on annual basis. However, the percentages of blood test results with risk and unsafe chemical levels were still exceedingly higher than the standard limit. Moreover, the method of health education provided only one-way communication with lacks of interaction between the farmers and the public health staff or among the farmers themselves.

There is a need for a more innovative strategy to reduce the risks of insecticide and pesticide toxicity among the farmers. This project adopted life skill teaching techniques by applying participatory learning in the occupational health work for agriculture area. It was aimed to change farmers' behaviors to correct and appropriate use of agricultural chemicals to prevent any hazardous effects to the farmers, to product consumers, and to the environment of Trakanphutphon District, Ubonratchathani Province for better quality of life in a long run.

1.2 Background

1.2.1 Classification of agricultural chemicals

Today, there are numerous chemicals being used by farmers. They can be classified into groups and the most common groups used are:

1. Insecticides.
2. Herbicides.
3. Fungicides.
4. Biological pest control agents.

1.2.2 Absorption and ways to enter the body.

For pesticides and herbicides to be able to produce harmful effects to humans and animals, they must be absorbed into the body mainly through 3 main modes, which are:

1. Absorption through skin

Absorption through skin is the most common mean for pesticides and herbicides to enter the body. Pesticides and herbicides can be absorbed through normal skin and at greater rate through wound or scratched skin. Fat-soluble pesticides and herbicides are normally absorbed through skin better than water-soluble ones. In addition, the absorption rate depends on the skin area being exposed to the chemicals. Pesticides are particularly well-absorbed at skin area with delicate tissues such as testes, underarms, ear cavity, forehead and head skin. Relatively less absorption occurs at hardened skin area such as forehand and forefoot.

Among the occupation group for which handling of pesticides and herbicides are necessary, hands have the greatest chance in becoming in contact with the chemicals. Therefore, uses of proper protective gloves and replacing when necessary after the used by date or damaged are one of the effective means to prevent absorption of the substances through the hands.

2. Absorption through the lung

Absorption of pesticides and herbicides through the lung occurs when the substances are inhaled. Quantity of the chemicals absorbed through the lung depends on the following factors:

1. Solubility: The absorption rate through the lung decreases with water solubility. That is, readily water-soluble pesticides are less absorbed than sparingly water-soluble ones.
2. Particle size: Pesticides and herbicides with fine particle size can pass through to the lung without retention in the nose, mouth, and bronchi.
3. Respiratory rate: High respiratory rate will increase absorption of pesticides and herbicides through the lung. For instance, the respiratory rate is normally higher during working activities than during sleeping, the absorption is therefore greater. However, in case of children whose average respiratory rate (5 m^3/day) is normally less than that of adults (20 m^3/day), the same dose of chemicals absorbed by children will produce higher dose/ kg than in adults due to considerably lighter body weight of children.
4. Volume of each individual inhalation: Greater volume of air inhaled each time will increase chance for the chemicals to pass through to the lung.

3. Ingestion/ absorption through the mouth

Ingestion of pesticides and herbicides may occur due to suicidal intention and a lack of knowledge, understanding, and cautions of people handling such chemicals, for example, food intake, drinking or smoking during working with pesticides. It may be resulted from accidents such as children playing with bottles of chemicals or drinking the chemical and so on.

Pesticides and herbicides taken through the mouth will be absorbed at the gastric track and the intestine. The absorption rate and part of digestive track where the pesticides are absorbed vary depending on properties of each type of pesticides.

1.2.3 General toxicity of pesticides to health

Pesticides of low concentration levels when entering the food chain can be accumulated into high concentration that could be toxic to human and environments. Table 1.1 showed examples of toxicity due to accumulation of pesticides in human and the environment.

General toxicity of chemical substances can be classified into 2 forms as follows:

1. *Acute toxicity*: Acute toxicity occurs when being exposed to large doses of toxic substances during a short period of time. Signs of acute poisoning vary depending on type of the chemicals exposed

Table 1.1: Examples of pesticide toxicity to human and environment.

Pesticides	Effects on human	Effect on environment
Insecticides		
Aldrin/Dieldrin	Spasm, convulsion, toxic to kidneys, carcinogens.	Tumour in animals, reproductive impairment in birds and fish.
DDT	Spasm, deterioration of central nervous system, and carcinogens.	Reproductive impairment in birds and fish, thin-shelled bird eggs, and tumour in animals.
Parathion	Acute toxicity	Kill wild animals.
Toxaphene	Chromosome mutation, carcinogens.	Accumulated in fish, inhibiting growth, and damaging fish livers.
Herbicides		
2,4 – D	Produce carcinogenic Nitrosamine.	Reduce habitats of wild animals.

1. Muscarinic effects include nausea, vomiting, diarrhoea, tear release, sweating, iris contraction, unable to control urine and excrement, contraction of bronchi, and excessive secretion of phlegm.
2. Nicotinic effects include spasms of facial muscles, eyelids and tongue. In severe cases, spasms could occur in all body parts.

Patients exposed to such chemicals at great extent may die due to respiratory failure. Moreover, some pesticides of organophosphate classes could cause toxicity to the nervous system after substantial period of time. This is commonly known as

Organophosphate – Induced Delayed Neuropathy (OPIDN). The toxic signs of such nervous system begin at the end of leg nerve cells.

Degree of toxicity depends on:

1. Types of pesticides. Some are highly toxic, while some are only slightly toxic.
2. Dose and concentration of chemicals being exposed.
3. Exposure modes such as ingestion, inhalation, or absorption through the skin.
4. Exposure period of the toxic substances.

2. *Chronic toxicity*: Chronic toxicity occurs after absorption of the substances for substantially long period of time. It may occur after a single prolong exposure to the toxic chemicals or after several exposures on continuous basis.

Summary of chronic toxicity of different pesticide group:

1. *Organochlorine insecticides*

This type of insecticides hardly decomposes leading to their persistence in the environment for a long period of time.

Chronic toxicity: Cancer

Anemia (Aplastic anemia – toxicity of Chlordane Lindane)

Reduction of sperm quantity – toxicity of Kepone

2. *Organophosphate and carbamate insecticides*

Insecticides of organophosphate and carbamate groups are considered to rapidly decompose compared with organochlorine insecticides and do not persist in the environment for a long period of time. However, organophosphate and carbamate pesticides produce highly acute toxicity due to their inhibitory effect on the functions of Acetylcholinesterase enzyme. The 1983 Food and Drug Administration Report and the 1985 Report of the Office of National Environment Board found the highest statistic of patients from toxicity of organophosphate pesticides than from other types of pesticides.

1.2.4 Toxicity in animals and environments

Pesticides that mostly affect animals in the environment are of organochlorine group. For example, DDT contaminated in soil will be accumulated in earthworms without producing any adverse sign to the earthworms. It is further accumulated in birds The organochlorine pesticides are the critical cause of decreasing in bird population with the actual cause of breeding reduction. Their acute toxicity could kill birds, slow the rate of reproduction, or even inhibit egg laying. The bird eggs have thin and fragile shell and their survival rate is low. This circumstance occurs in the area where low concentration of organochlorine pesticides is used. This type of pesticides would disturb calcium metabolism of the birds possibly by inhibiting the functions of Carbonic anhydrase enzyme. This mechanism reduces sufficient amounts of calcium, necessary for eggshell development process, which occurs at greatest rate within 20 hours before egg laying activity, so resulting in thin eggshell. Measurement of eggshells of the birds in the museum found that the thickness and weight of the

eggshells were constant throughout until during 1937 – 1947. After that period, the thickness and weight of the bird eggshells had dramatically decreased, corresponding to the time when the application of organochlorine pesticides became popular. Moreover, this type of pesticides delay the time of egg laying possibly by inhibiting production of liver enzymes and so reducing the amount of estrogen hormone in blood.

Organochlorines could be toxic to fish. For instance, during the end of the 1940's (1947) great deals of fish in the Mississippi River were killed. Catfish, which are sensitive to Endrin toxicity, were killed due to a spray application of the chemical in sugarcane fields in that area. Analysis of the water quality did not find any abnormality in pH value, DO, temperature, or other diseases; however, Endrin was found in sediments of the river.

Herbicides have adverse effects on the environment at similar severity as insecticides do. The evident example was military practice of the Americans in Vietnam. The result from the 1961 experimental program was first practiced in 1962 with the maximum practice in 1971. The practice used the chemical known as Agent Orange, which was a mixture of 2,4-D and 2,4,5-T and Agent White, which was a mixture of 2,4-D and Pichloram. Another largely used chemical was Agent blue, which was an herbicidal mixture between arsenic compounds and Cacodylic acid, intentionally mixed to destroy plants and vegetables grown by Vietnamese. Approximately 2,000 square kilometers of vegetable land were destroyed resulting in one-year shortage of food for 600,000 Vietnamese people who were then considered the American opponents. Furthermore, spraying of those chemicals to de-leave trees

produced fine chemical sprays that contaminated and destroyed vegetables greatly causing psychological effects to the communities.

The Herbicide Assessment Commission under the American Association for the Advancement of Science in the U.S. conducted a national survey on Vietnam in 1970. The survey found that approximately one fifth of the forest area or half of the total wetland forest, accounting for approximately 1,400 square kilometers were destroyed. All plant populations were entirely destroyed by a single spray. It was yet questionable that, except for plants with non-economical value and certain types of ferns, there was no evidence of other plants able to grow in that area for several years. At least several decades are required to reconcile the forest condition to its original state.

The laboratory studies found that dioxins were toxic to embryos and reproductive system, responsible for deformity of newborn infants, and were animal carcinogens. There was also strong coincidence for an abortion rate of pregnant women who lived nearby the forest area where 2, 4, 5-T was sprayed to control unwanted plants in Oregon State.

Regarding persistence, dioxins are persistent in the environment. For instance, eggs of the birds living in the area of Great Lakes contained 9-90 ppm of dioxins and 21 out of the total 62 fish samples collected from the same lake area contained accumulated dioxins. However, a carcinogenic potential of the phenoxy herbicides might not be resulted solely from dioxin contamination, but, possibly due to the phenoxy compounds themselves. Although the phenoxy compounds did not cause

genetic mutation, the abnormality caused by these compounds was due to the resulting H_2O_2, which could form excessive peroxisome in the liver to the level that is harmful to DNA and could eventually induce cancer.

1.2.5 Side effects of pesticides

Spread of the pesticides in the environment as mentioned above could have several adverse effects on the environment and on the ecosystem as outlined in the followings:

1. Adding problems

Once pesticides are used to wipe out one species, this reduces competition among other species in the same ecosystem. Insects or plants, which are not affected by such chemicals, will rapidly grow to replace the area. This phenomenon results in evolution of new unwanted insect species that are different from the originals possibly with equivalent or greater severity. It can be said that once human destroy one species to its extinction, this stimulates a replacement evolution of a new species.

2. Increasing resistance

Similar to the reason mentioned above, once pesticides are used, species with no or little resistance will be destroyed. After each generation, insects especially the species with shorter life span than the plants will gradually adapt their genetic contents and become better resistant to the regularly used pesticides. Pest control using the same chemicals requires more and more chemicals over time. Although the unwanted plants have longer life span than most insects, their adaptation of genetic

resistance could also occur in the similar manner. It is notable that unwanted plants or insects could develop their resistance to the effect of the pesticides being used regularly. Therefore, two means of resolution may be derived from that observation. These are 1) Circulation/ change of pesticide groups possibly every year to lessen chances for genetic resistance development 2) Circulation of crops constitutes indirect circulation of pesticides as different crops may require different types of pesticides, which are not harmful to the crops and able to control their enemies that may also be of different species.

3. Increasing doses of pesticides

This problem is a consequence of development of genetic resistance mentioned previously which leads to requirement of more and more pesticides in order to produce effective results. Another causal factor is that modern agriculture requires less plowing frequency, which is considerably disadvantageous for pest and unwanted plant control, as plowing helps to terminate life cycle of plants and insects incubating in the soil. When there is no or only few number of plowing, those crop enemies are allowed to increase their populations. Elimination of unwanted plants by covering the soil surface could provide habitat and suitable conditions for insects to lay their eggs. In addition, application of herbicides could kill other non-target plants that used to be habitats for insect predators. The evident example was an application of herbicides to control unwanted plants at a fence line, in garden areas, or in fruit gardens. That had led to more damages from an outbreak of fruit insects as the predators living in those areas lost their habitats and became decreasing in the number of population allowing

the insects to spread out. The farmers, therefore, needed to use insecticides in addition to the previous application of herbicides.

Another example of side effects due to application of pesticides is a change in ecosystem complexity. When agriculture by a minimum-tillage method is popular as at present, soil-microorganism activities increase as the system produces more carbon and nitrogen sources for microorganisms in the soil. However, when herbicides are used continuously, microorganisms in the soil will produce enzymes to break down those compounds. This phenomenon also occurs with insecticides, as chemical properties of several herbicides are similar to those of insecticides. Therefore, greater quantity of the herbicides and insecticides are needed for effective results.

4. Reducing motivation

Utilisation of herbicides is one of the factors in reducing farmers' motivation to circulate crops. The main objectives of crop circulation are to add plant nutrition to the soil and to lessen numbers of plant diseases and insects. The key factor driving farmers to circulate crops is a turnover or profit gain. However, application of some herbicides could reduce the amount of the same crop's enemies in the next growing season, the farmers; therefore, decide to grow the same crop as it gave better yields.

A good example is application of Atrazine, which is one of the mostly used chemicals today, in cornfields to control broad-leaved grasses. Atrazine can persist in the soil, possibly for as long as 17 months. Therefore, uses of Atrazine lessen chances

of broad-leaved crops growing, especially soybeans, which are highly sensitive to toxicity of Atrazine. The persistence of Atrazine leads to farmers' assumption that by re-growing corns in the next growing season, the cost for herbicides is reduced and potential risks of losses from growing broad-leaved crops are minimised. Utilisation of Atrazine in cornfields, thus, induces additional motivation for farmers to grow the same crop in the same area.

Most herbicides have low persistence in the soil with losses of effects at the end of growing season. However, there are several types of herbicides such as Pichloram and Monuron, which can persist in the soil for up to 2 – 3 years. The chemicals with high persistence in the soil will lessen chances of crop circulation due to their adverse effects on other non-target plants as mentioned above.

5. Effects on plant diseases

Another drawback of herbicide application is possible enrichment of harmful plant diseases. This could occur through several mechanisms. For instance, herbicides may reduce the crop tolerance to diseases caused by one of the following effects: reducing wax production of leaves, changing metabolism of carbohydrates, of nitrogen, or of glucoside. They may also reduce or stimulate particular growth of the crop that facilitates disease development. For example, application of 2,4-D for cornfields could possibly lead to an increase in corn leaf blight diseases, as 2,4-D stimulates protein accumulation in corns that facilitates development of corn leaf blight diseases.

6. Supplementary effects

Some types of herbicides enhance toxic effects of insecticides and some even enhance effects of herbicides themselves. Research in this area currently receives little attention, though there should be studies on co-effects of the target chemicals on other non-target chemicals, on ecosystems of living organisms and so on, including studies on tendency of hazard potentials to humans and environments.

7. Effects on other non-target species

The target group for pesticide application by humans is the plants' enemies. Humans are also destruction targets of the chemicals because humans are the chemical users and are the consumers of the products. For example, when DDT was extensively used during the World War II, significant amounts of DDT and chemicals of organochloride classes were found in human fat tissues. Moreover, during 2, 4-D herbicide popularity period, the 1965 survey in the Unites States reported that the populations consumed an average of 0.001-0.05 mg of 2, 4-D daily from vegetables.

1.2.6 Quantity magnification in a food chain

Distribution of pesticides in the environment leads to accumulation of such chemicals within a food chain in multiplied quantity. For example, dispersal of DDT into waterways contributes to DDT concentration of 0.005 ppm in the water. DDT enters the food chain resulting in an accumulated amount of 0.05 ppm in plankton. This is a magnification process of DDT concentration in the food chain. Until it is contaminated in fish eating birds, the concentration of DDT may be as high as 25 ppm.

1.2.7 Pest control using natural herbs

There is a trend for conservation of natural resources and environments in the current society. Environmental pollution has, at the same time, become more and more severe because of both direct and indirect human exploitation. Moreover, it cannot be denied that agriculture activities employing chemicals in the production process does not cause environmental changes. That is because prolong and continual uses of agricultural chemicals will result in contamination of toxic chemicals in the environment and eventually affect humans who are the chemical users and the product consumers. Because of the above reasons, farmers today become more interested in applications of natural herbs for pest control.

There are several types of herbs used in pest control applications. The most commonly used ones are margosa, citronella grasses, galingale, and anamirta or a fish poison.

Margosa or nim tree

Is a rapid growing plant with medium to large sizes. Its origin was believed to be from India and Burma with later distribution to various tropical countries. It can grow even in the area with poor soil but its growth development could be retarded in wet soil.

There are three types of nim trees found in Thailand. These are Azadirachta indica A. Juss, Azadirachta exceisa Jack, and Azadirachta indica A. Juss var. siamemsis Valuon.

Nim trees have properties for pest control and prevention because various parts of the tree, such as bark, stem, leaf, fruit, and seed, are found to contain more than 60 types of substances. These substances can be classified into 5 groups by their chemical structures. The majorities are Triterpenoid compounds, especially three types of Limonoids (Tetratripenoids), namely, Azadirachtin, Salannin, and Nimbin, which mostly found in the seed. In unripe fruits, the seeds will largely contain Salannin while Azadirachtin quantity will be increased in ripe fruits. In 1986, these three compounds were reported to have pest control properties, especially Azadirachtin. They have adverse effects on several insects. For instance, Salannin, and Nimbin possess properties to repel insects and retard their feeding, growing and sloughing process. They also inhibit hormones in the insects to prevent egg production and laying. The property of sloughing inhibition is more critical than the property to repel and inhibit feeding activities in killing the insects. The effect mechanism of margosa is different from that of insecticides as margosa would not kill the insects instantly but will slow down their activities such as slowing down their feeding activity until completely inhibiting the activity. The insects are unable to slough and eventually die.

Collection of margosa fruits and preparation of margosa seeds

Margosa cannot be used directly. Only quality seeds can provide maximum effects of insect control. To prepare and select good quality seeds, firstly, ripe margosa fruits (indicated by yellow or green-yellow colour of the fruits), may be collected by shaking the tree to release its fruits onto underlined plastic sheets. The next step is segregation of the flesh by squeezing the ripe margosa fruits to remove the flesh. The fruits may be stored in a plastic bag for 1-2 days for easier separation of the flesh. After

that, the seeds are squashed with sand to further remove any remaining flesh and then cleanly washed with water. Then the seeds are thin-spread in the sun to rapidly dry for 5-7 days prior to airing in shade. The seeds can be kept for 1 year by storing in a net bag with good ventilation in a dry and cool place with no humidity at temperature between 21-22 °C.

Uses of margosa

1. *Agricultural purposes*: the seed can be applied in several ways. For example, powder of margosa seeds can be used to sprinkle around plant trunks to prevent underground insects, various worms, and earthworms. Margosa powder mixture (1 proportion of margosa powder: 1 proportion of wood shavings or dry clay) can be dropped onto leaves of young corn trees or sorghum trees. The mixture will dissolve when receiving water and be effective in preventing perforation of buds and stems by worms. Margosa may also be applied in a storehouse to protect crop seeds from pests and insects during storage by mixing the crop seeds with margosa oil at the ratio of 10 cc margosa oil to 1 kg crop seeds.

Regarding effectiveness of margosa on insect control, firstly it was found to be highly effective on some types of beetle larvae and butterfly and moth caterpillars. Secondly, it is well effective on grasshoppers, leaf miners, and leaf and plant hoppers. Thirdly, it is moderately effective on some types of adult beetles, aphids, and white flies. Fourthly, it is slightly effective on fruit flies, various bugs, and spider mites.

Farmers can simply extract substances from margosa seeds by grinding the seeds into fine powder. One kilogram of the powder is mixed with 20 liters of water with occasional stirring and allowed to soak for 1 night. Then, the mixture is filtered through several layers of thin linen sheets. The filtrate water after mixed can be sprayed onto target plants. The liquid extract should not be kept for longer than 2-3 days due to possible deterioration. Today, margosa can be processed into instant concentrated products, which required dilution with water prior to spray application. This is highly convenient for the users as no domestic extraction is necessary.

2. *Industrial purposes*: Margosa trees of Azadirachta indica A. Juss var. siamemsis Valuon and Azadirachta exceisa Jack types have straight trunks so suitable for uses as a main pillar or for furniture. Margosa of Azadirachta indica A. Juss type is commonly used for firewood. Oil extracted from margosa seeds, which contain as high as 35-40 % of oil, can be used as a lamp oil, a lubricant, and in soap industries. Margosa can be useful in skin-tanning industries by using Tannin extracted from the bark.

3. *Medical purposes*: Margosa oil was found to be useful for treatment of fungicidal and bacterial diseases, whereas the leaf is effective for treatment of Malaria.

Citronella (Tra-krai-hom)

Citronella belongs to the same genus (Gramineae) as rice. Its scientific name is Cymbopogon nadus (Linn) Rendle. Different regions will name the plant differently such as "Ja-chi-magrud", "Tra-chi-makrud" or "Tra-krai-dang". Citronella is easy to

grow and require little caring. It contains essential oil with a unique scent in the leaf and the stem.

There are two citronella species commonly extracted for oil. Those are Lanka species (Cymbopogon nadus Rendle) and Java species (Cymbopogon winterianus Jowit), which are commonly grown in Thailand.

Cultivation and nurture process

Citronella can grow well in every type of soil and tolerate drought condition. Citronella sprouts suitable for transplanting should be cut leaving 2-3 joints below the outer leaves and should have 4-5 leaves covering the bud. The tip of the leaves is removed prior to transplanting. Distance 1.5 x 1.0 meters should be allowed between each stem. Citronella should be grown in open area with full sunlight, as it is a type of plant that likes strong sunlight. The suitable growing season is during the beginning of rainy season. If there is recession of rain, water should be given as required. Unwanted plants may be eliminated during 2-3 months after transplanting. In case of fertile soil, addition of fertilizers may not be required during the beginning period. Fertilizers with blended formula such as 16-16-8, 16-20-0, or 15-15-15 may be added after several product harvests. Uses of fertilizers again depend on fertility of the soil. After cutting the leaves, urea or ammonium sulphate fertilizers may be added at the proportion of 15-20 kgs per Rai to enhance germination of new leaves. They will also increase leaf sizes and quantities of essential oil. It was found that there are no diseases or insects that could reduce productivity of citronella.

Harvesting

Harvest of citronella is done by cutting the leaves at 25-30 cm above the ground. For rapid generation of new leaves on the remaining stems, cutting of the leaves should be done on 3-month interval basis. The harvested leaves must be left for 1-2 days prior to the oil extraction process. If the leaves are not cut after 7 months of age, the lowest leaves will begin to dry out with the 4:1 weight ratio of fresh leaves to dry leaves. This natural method could give a total productivity of 450 kg/ Rai. Fresh leaves can be extracted for essential oil by steam distillation for 30 minutes. That is, after water is boiling, the essential oil is separated from the water yielding approximately 1.42 % of crude oil. The stem part normally yields 0.5 % of crude oil. Citronella grown in sandy-loose soil with well caring and the planting distance of 1.0 x 1.0 m or 1,600 trees/Rai, if each cluster contains 130-150 trees, will yield fresh leaf productivity of approximately 8,000-10,000 Kg/Rai for each harvest on every 3 month basis.

Uses of Citronella

1. Agricultural purposes:

Filtrate liquid obtained from fermentation of fresh fully mature leaves with fresh galingale and margosa leaves can be sprayed for pest control in vegetables, rice, and some fruits such as orange and longgong. Fully mature leaves, fresh or dry may be used for barn-ground lining to prevent invasion of insects in a storehouse. In addition, an extract from the stem and the leaf can be used to repel insects.

2. Industrial purposes:

Citronella is used in manufacturing industries of soap, shampoo, synthetic odors, wax, and odorants. There were data indicating that a demand for citronella essential oil was as high as 15 tons each year in Thailand. This amount cannot be sufficiently manufactured from within the country; therefore, some must be imported from other countries mainly from England and France.

3. Medical purposes:

Citronella essential oil is sprayed to repel mosquitoes and used to manufacture mosquito-preventive lotion. It is also used for treatment of stomatitis and indigestion.

Galingale

Galingale is a plant that is used as spicy herbs and flavour additives for several types of foods for a long time. It belongs to the Zingberraceae lineage with the scientific names of Alpinia galangal (Linn) Sw. and Alpinia offcinaram Hance. Different regions name the plant differently, for example, "Kha-dang", "Kha-yuak" (Northern), "Kha-luang", and "Sa-er-kery" (Maehongson province). Galingale is considered to be a plant of Tropical region. It is generally found as a common domestic vegetable in Thai households.

Galingale is a short-lived plant with several years of life span and approximately 1.5-2.0 m height. Its underground root has white colour with apparent joints. The inner flesh of the root has yellow colour with a unique scent. Galigale leaf is

of a single leaf type, arranging by alternation of the waxy side. The outer leaves wrapping the stem have spear shape. The leaves are oval long leaves with approximately 20-40 cm width. Its flower occurs at the peak. The flower is of small size with creamy white colour and possibly with red dots on the large pedals. The fruit has oval shape with approximately 1cm in diameter. There are approximately 2-3 seeds inside the fruit. Galingale is commonly reproduced using the root. It does not like water-holding area. They can be planted when the soil is loose, recommended during beginning of rainy season.

The galingale root contains approximately 0.04 % of essential oil, which is composed of several compounds such as Methyl cinnamate, Cineol, Eugenol, Camphor, Pinenes and so on. The essential oil has bacterial resistance properties while a galingale alcohol extract has properties of fungicidal resistance.

Uses of galingale

1 Agricultural purposes:

Liquid obtained from fermentation of fresh citronella leaves with fresh galingale root and margosa leaves can be sprayed to control insects in vegetables, rice, and in some types of fruits.

2. Medical purposes:

Galingale has properties for treating of indigestion with the simple preparation as in the following steps: Use the root with a size of a thumb (fresh weight of approx.5 g or dry weight of approx. 2 g), slightly bash and boil in water. The

resulting herbal water is ready for drinking. Alternatively, use a mature root, finely grind, then mix with 2 cups of limewater, stir and filter the liquid through a white linen sheet. Drink half a cup of the liquid at a time. It can also be used for treatment of skin diseases such as ringworm and liver spots by using a mature root, slight bashed or cut into thin slices, fermented in ethyl alcohol for 1 night, and then apply onto the infected area. Today, galingale is processed into treatment cream products for convenient uses.

Anamirta or a fish poison.

Anamirta is a climb plant of a hard wood type, belonging to the Papilonaceae lineage. Its scientific name is Derris elliptica Benth. Various names are given in different regions including "Oward-nam", "Lhai-nam" (Northern), "Po-ta-kra" (Karen-Maehongson province), "Hang-lhai", "Ka-la-paw" (Petburi province), "Crer-lhai-nam", and "Hang-lhai-dang".

The effective compound in anamirta is Rotenone, which has insecticidal effects on some types of flies, mites, and worms. Anamirta is toxic to fish, but non-toxic to warm-blooded animals. It is easily degradable, so does not result in chemical contamination in the products, which is, therefore, safe for consumers.

Uses of anamirta

For agricultural purposes, anamirta is prepared by using the root, hard ground or bashed, to soak in water with the ratio of 1 Kg anamirta to 20 liters water then allow fermenting for 2 days. During the fermentation period, the mixture should be stirred using a wood stick for 3-4 times. After 2 days, filter out the solid materials. The liquid

filtrate is used to spray onto plots of various vegetable lands and fruit gardens. Its application is not recommended on the area nearby water sources as it could cause death to fish.

1.2.8 Participatory learning

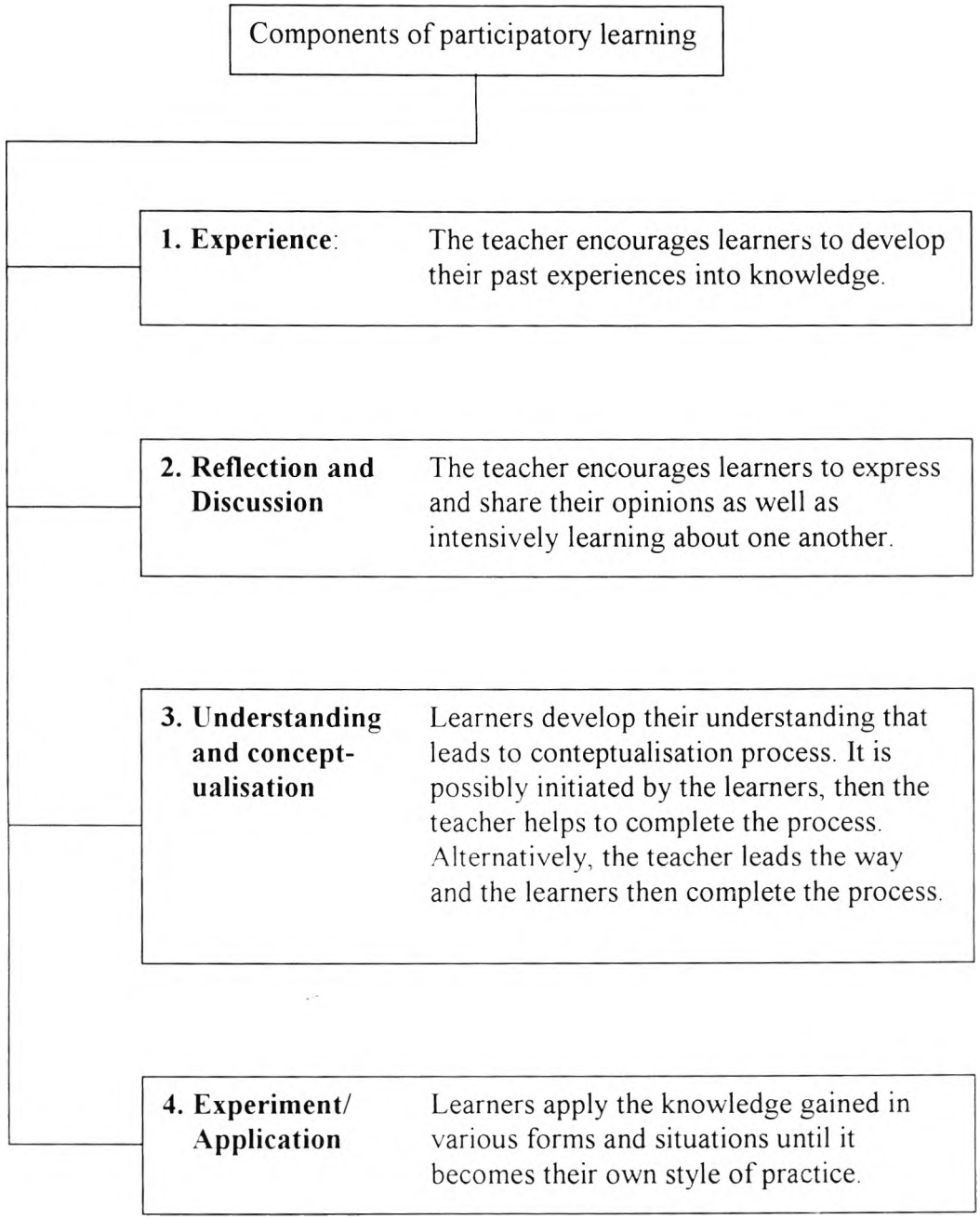
Participatory learning in this study is a process to empower and raise knowledge by encouraging the participants to share their ideas, experiences and knowledge with each other. It enables them to identify their knowledge and make decision on pesticides use and develop core practices under openness atmosphere between the facilitator and participants.

Concept of participatory learning

Participatory learning is an effective learning and teaching method for best development of personnel in terms of knowledge, attitudes, and skills. A primary structure of participatory learning comprises of an experiential learning process in combination with a group process. Since every learner has his/her individual past experiences, which could be adopted at their maximum benefits through processes of group discussion as well as of experimenting the knowledge in actual practice.

Participatory learning is a learning process, which focuses on learners as the learning center, comprising of the basic principles as shown in Figure 1.5.

Figure 1.5 Component of participatory learning



Source: *The Handbook of Life Skills Teaching for AIDS prevention*. Ministry of Public Health. Ministry of Education. and Ministry of Defense. 1996.

Based on the components illustrated in Figures 1.5, education by participatory approach consists of key principles when may be described follows (Bishop et al, 1998 and Amold and Burke, 1983):

1. Learning and teaching emphasises on encouragement people to see a relationship between themselves and the surrounding and to believe that they are able to initiate changes to their health, to the community, and to the society.
2. Learning is initiated from experiences of the learners who are allowed to think and analyse by integrating people's problems with social factors that cause the problems.
3. Learning allows actual participation of the learners in every step from i) selecting learning topics that are important to the learners as well as being of their interest, ii) participation in activity planning, in activity organization, in learning ,and in self-assessment, and iii) evaluation of projects/learning activities Group learning is when every learner teaches and learns from one another by having teachers as learning supporters or coordinators. The learners are able to mutually exchange their knowledge, ideas, and experiences. There is collaboration in planning and problem solving or in changing things according to their needs.
4. Learning initiates changes by encouraging the learners to participate in planning of activities for a change purpose.
5. Learning and teaching is a flexible and continuous process with adjustment of content, method, and learning media to suit the needs of the learners and of the group. Moreover, the learning is not limited within the classroom as

the learners can learn new things from real experiences and self-practices at all time.

6. Learning and teaching is entertaining and interesting, at the same time having clear learning objectives for each activity.

Teachers have key roles in participatory learning and they are as follows:

1. Teachers of participatory learning must adapt their roles to be coordinators and learning supporters rather than being teachers or knowledge providers.
2. Promoting learning by organizing the learning atmosphere that persuades maximum participation. There are exchanges of experiences and opinions, which lead to development of new knowledge.
3. Promoting development of ideas and practical skills in order to initiate changes at personal and social levels.
4. Teachers and learners each learn from one another by considering others as their sources of knowledge and ideas.

Participation of the group will lead to learning process, which in turn will lead to behavioral changes for people in communities to eventually have good health. However, a teacher of participatory learning must understand the concepts and principles of participatory learning, as well as being able to apply techniques and contents to suit a particular group of learners and a target task.