CHAPTER II

LITERATURE REVIEW

2.1 Local knowledge in insect pest management

In agricultural production, insect pests are always a standing worry of the farmers. Basing on local knowledge and renovations of technique and science, the farmers are always looking for new methods to prevent and control efficiently insect pest or seeking alternative methods for overusing pesticides in order to maintain pest densities below levels of unacceptable injury and reduce the costs.

The most popular insect pests on the litchi are the litchi stinkbug (*Tessaratoma papillosa* Drury), fruit-piercing moth (*Othreis* sp.), and fruit borer (*Acrocercop crameralla* Smellem) in China. In order to control insect pests effectively, the farmer applied pesticides and orchard cleaning. Some activities in the orchard cleaning include weeding the orchard, loosening and sun drying the soil, winter pruning, burning the weeds and pruned twigs, and soil application of lime or bagging the fruit clusters. Some measures can be used to control and manage them such as the use of dichlorvos 90% at rate of 0.1% spray in March and May to control the litchi stink bug. Besides the use of pesticide, capture and kill adult of the litchi stink bug, picking up bunches of egg, use of beneficial bee to parasite the litchi stink bug's egg, tree hygiene, understanding rules of occurrence and spreading to be able to apply insecticide in time (Nghe and Ngo, 1991).

In Thanhhoa and Quangninh, Vietnam, 77 litchi insect pests and 27 beneficial insects were discovered. The most important insect pests can be listed such as green looper, litchi stinkbug, fruit piercing grey moth, fruit borer, and longicorn beetle. The most significant beneficial insects to control population of insect pests in benefit threshold are ladybug, yellow-eye bug, and parasitical bee. Besides of these, litchi farmer applies many different methods to control insect pests. They can use bait of sugarcane juice with cypermethrin (25 EC: 0.2%) to kill fruit piercing moth or strong intensity of the light to drive them away (Nguyen, 1999b).

Regardless of where litchi is grown, several insect groups attack many parts of litchi tree such as the flowers, fruit, leaves, and branches. Lepidopterous fruit borers (*Conopomorpha sinensis* Bradley) are generally the most important insect pests affecting litchi production. In order to control this pest, Thailand growers inspected weekly the fruits from fruit set forward to detect the egg. Infested fruit is picked and destroyed. When the pest is more active, permethrin applied weekly up to two weeks before harvesting (Menzel, 2002).

2.2 Insect pests in litchi orchards

Nowadays, litchi is a cash crop and brings about many benefits for litchi farmer. In order to achieve this, litchi farmer had to use a lot of inputs to intensify the crop and increase productivity. However, insect pests have also followed closely with intensification and development levels and damaged increasingly.

Insect pest species are very dangerous to the litchi tree, they damage branches, shoots, flower, and fruit. There are as many as 19 litchi insect pest species in areas of Hanoi, Haihung, Namha, and Yenbai, in which litchi stink bug, white scale, litchi piercing moth, and fruit borer are the most important species on the litchi. The attack of these species occurs mainly in reproductive cycle of growth. They cause reduction of litchi fruit quality, dropping, stunt growth plant, leave yellow, wilt and die. Among the litchi insect pests, litchi stinkbug infestation normally reduces the fruit yield by 20-30%, and maybe reduces by 80-90% if the infestation is heavy. The very serious damage and massively dropped fruit would impact immeasurably on yield if controlled late. Another side, if spraying is in time can keep 30.03 fruits per branch; if this is later 10 days remaining fruits are only 17.63 per branch (Tran *et al.*, 1996).

Although litchi farmers applied a great deal of pesticides, most of the litchi trees were heavily affected by a number of pests in Thailand. The major pests were the litchi fruit borer (*Conopomorpha sinensis* Bradley), litchi erineum mite (*Eriophyes litchi*

Keifher). In addition, litchi was also attacked by a number of caterpillars, which feed on the leaves, flowers or fruits. Approximately 100% of litchi trees were infected by the litchi erineum mite (*Eriophyes litchi* Keifher), leaf beetles (*Monolepta* sp.) and around 50% were damaged by a bark-feeding borer (*Indarbela* spp.). During the harvest season in April 2001 there were up to 30% of litchi fruits to be damaged by litchi fruit borer and other lepidopterous larva (Schuetz *et al*., 2002).

Damage rate of insect pests is quite different depending on their occurrence time (season) and environmental conditions. In an effort to determine this and composition of insect pests on the litchi in Hanoi and adjacent area, some Vietnamese researchers investigated and collected 51 insect and mite species, in which there were 46 insect species, the rests were mites. The fruit borer was an important insect pest on the litchi. Percent of damaged fruits in early season was from 0.7 to 3.2 in year 2001 and up from 23.7 to 36.5 in year 2002. Rate of damaged fruit could be up from 37.6% to 45.8% in main season and from 65.2 to 78.4% in late season of year 2002 (Dao *et al*., 2003). However, The most important species include fruit borer, litchi stinkbug, looper. These 3 species attack almost above ground important parts of litchi such as flower, leaves, and fruit and damage seriously on tree's growth, development and yield (Nguyen and Tran, 2004).

2.3 The strategies for managing insect pests in litchi orchards

Present-day growers are equipped to protect their crops from excessive damage, and they can draw upon a large body of knowledge and management options, both preventative and curative. Some of them have extensive knowledge about the ecology of pests and their natural enemies in cropping systems. They have a long experience in the use of cropping plans and cultural practices for deterring pests. There is a wide choice of effective chemical pesticides – which should, however, be used judiciously to minimize deleterious side effects. There is the challenge, therefore, of combining the available management options in the most appropriate way into the practical business of day to day farming. So how to design systems for integrated pest management (IPM) can be formulated at different temporal and spatial scales. The management decisions that growers make for their crops in any field and at any time during the season are embedded in the larger framework of what their plans are for their entire farm operations over a time frame of 1, 2 or many years. Integrated pest management is one of strategies to maintain and develop litchi production with high yield and good quality. As with all crops, the ultimate aim in the protection of the litchi crop from insect pests is to implement a viable integrated pest management system. The tactics adopted against each pest depend on how well they fit it with the overall management strategy for an orchard. Natural enemies may effectively control some pests and the control of the other insect pests must always take into account the possible side effects on these, and the possible induction of pest problems caused by injudicious use of insecticides (Waite and Hwang, 2002).

Insect and mite pests are always attacking on litchi in Asia. They can attack the flowers, fruits, leaves and branches. The most important insects affecting on production are *Lepidopterous* stem borers. Besides this group, some other important species such as leaf- and flower-eating caterpillars, beetles, bark borer, scales, leaf mites, fruit-sucking bugs, fruit-piercing moths and fruit flies. So the strategy for controlling the litchi fruit borer (*Conopomorpha sinensis* Bradley) is to inspect weekly from fruit set to detect eggs and infected fruit in order to pick and destroy at infestation levels of 1 to 2 percent. When the pest becomes more active, permethrin is applied weekly, up to two weeks before harvest. Besides this, many other methods such as chemical, biological, and cultivation should be also used to manage and control other important insect pests in the litchi production (Menzel, 2002).

Pest management in crop production is the most problem. How to manage effectively pests but reduce cost, so the farmer must understand and build a strategy to deal with the pest. There are many strategies such as cultural practices, biological controls, and chemical methods the farmer can use and combine harmoniously to manage pest. Besides these, they also suggested that some management activities such as field scouting and pest identification, keeping field records, weather conditions and pest/crop response should go together with the strategy (Runyan and Wright, n.d.).

In order to reduce cotton protection costs and to improve overall pest control decision-making at the farmer level in the insect pest management system for current cotton in francophone African countries, different pest management strategies were studied aimed at timing and limiting insecticide applications. The strategies focused on using control thresholds early in the season, reducing the dosage in mixtures, or using single active ingredients instead of mixtures. These strategies were shown to be effective over the current protection program of the area. The number of treatments and the amount of insecticides applied were reduced while achieving equal or better pest control and yields and being safer to some beneficial arthropods (Ochout *et al.*, 1998).

In Quangdong – China there were two major insect species only before 1960s, the litchi stinkbug (*Tessaratoma papillosa* Drury) and the litchi stem-end borer. Main reason for limitation of major insect pests was to be suppressed by a high population of natural enemy and unpopular use of insecticides. After 1960s, many insecticides that are very harmful to beneficial insects used, with shortage of knowledge, massive and unwise use of the insecticides resulted in devastating environment, beneficial insects as well. So IPM can efficiently control insect pests by researches on the bionomics and toxicology of the major insect pests, the occurrence of insects, and real situation of litchi orchard. Insecticides should be targeted at the control of the major insect pests and the reduction of the damage to the ecosystem (He, 2000).

In order to form a cost-effective pest management strategy for cowpea growers in Uganda, influence of different times of planting and plant densities on infestation levels of the major pests of cowpea and frequency of insecticide application was established and examined. When applying a single insecticide at budding, flowering and podding had the highest marginal returns (3.12) in comparison to spraying throughout the season (1.77) and at seedling, flowering and podding stages (2.18). Cowpea grain yields and marginal returns from plots receiving combined control measures were higher than those from plots receiving only cultural or chemical control measures. This provides evidence that a few well-timed sprays in combination with cultural practices are not only effective but also very profitable (Karungi *et al.*, 2000).

Application of synthesized insecticides is too popular in the orchards in Vietnam. However injudicious and unwise application of the insecticides had resulted in killing beneficial insects and resisting to insecticides from the pests. In an effort to reduce pressures on insecticide selection for controlling insect pests and litchi stinkbug's resistance to trichlorphon in China, a mixture of Chlorpyrifos and Cypermethrin (10:1) was tested against adults and nymphs (Table 2.1). The results showed that this mixture could be used as an alternative to the Trichlorphon for the control of both over-wintered adults and nymphs (Xin *et al.*, 2000).

Table 2.1 Efficacy of the insecticides against over-wintered litchi stinkbug adults

Treatment	Day1	Day 3	Day 7
	...................mortality (%).................		
Chlorpyrifos and cypermethrin			
138 ppm	81 b	94 a	100
366 ppm	89 a	95 a	100
550 ppm	91 a	98 a	100
Trichlorphon 1,125 ppm	92 a	100 a	100
Control	0 c	0 b	1

Source: Xin *et al.*, 2000

However to control the litchi pests, it is necessary to manipulate agricultural technical, biochemical, chemical, physical, mechanism measures to restrain the sources of the pests under economic threshold, to protect beneficial insects, to keep biological balance and unpolluted environment (Tran, 1999):

- Agricultural technical measures: Changing extensive farming customs by intensive technical measures to enhance pest resistance of the tree, improve orchard environment, make more condition to development of the beneficial insect and agents.

- Biological measures: protecting and importing beneficial creature to control the pests in the litchi orchards.

- Chemical measures: it is necessary to use pyrethroid and chemically based pesticides to stamp out nidus. It should choose pesticides that effective on the pests and suitable with the purpose, reasonable concentration, and choose the time and technique to apply effectively.

- Physical and mechanism measures: this is measure requiring more labor, industrious, and creative to scrap off or smash, catch such as the egg, as well as larvae of the pests.

Today integrated pest control forms the foundation of IPM that takes a comprehensive and multi-disciplinary approach to solving pest problems. Insects, weeds, plant diseases, and even some vertebrate pests (e.g., birds and rodents) are included under the IPM umbrella. These programs emphasize management rather than eradication. They take a broad ecological approach to pest problems, focusing on all members of a pest complex in an effort to identify the optimum combination of control tactics (Figure 2.1) that will reduce pest populations below economic thresholds. Besides this they also maintain the levels with the least possible impact on the rest of the environment. This approach, often called biorational pest control, relies heavily on cultural and biological tactics that are supplemented with carefully timed applications of highly selective chemical weapons (Meyer, 2003).

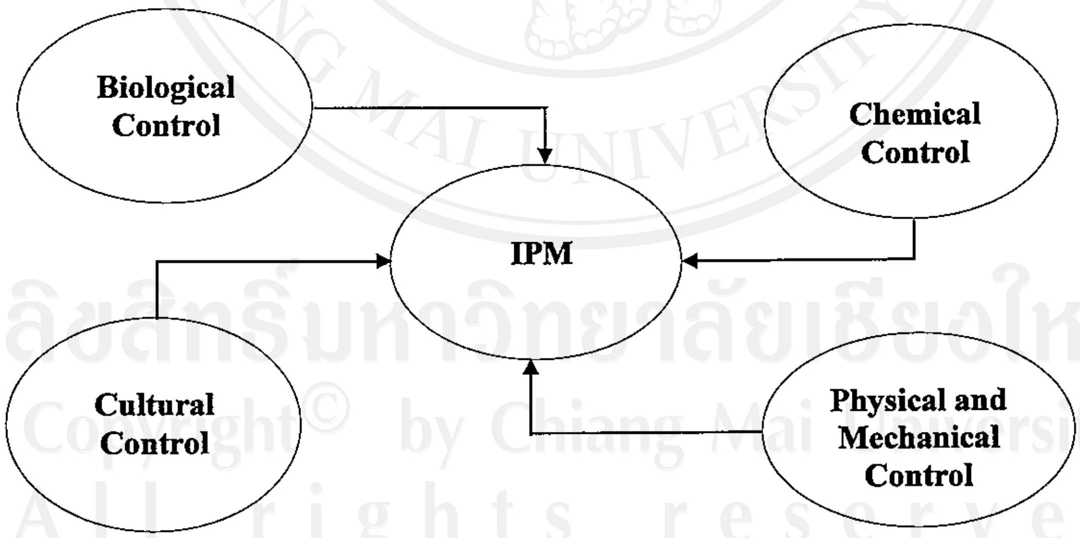

Figure 2.1 Composition of Integrated Pest Management

2.4 Management options

In agricultural production, insect pests are always a standing worry of the farmers. With renovations of technique and science, the farmers are always looking for new methods to prevent and control efficiently insect pest or seeking alternative methods for overusing pesticides in order to maintain pest densities below levels of unacceptable injury and reduce the costs. All litchi orchards are inhabited by a diverse array of organisms including insects, spiders, mites and small animals. Most of these cause little or no damage and are generally considered non-pests. Only a few of the insects and mites at present are actually plant feeding pests. Because of the wide diversity of species and the many similarities between pests and non-pests, it is important to be able to distinguish incidental and beneficial species from target pests. Pests should be detected before they reach damaging levels. This can be accomplished through frequent inspections. Because the orchard is similar to a natural eco-system and more stable than a field for rice or vegetables, it is really necessary to combine between IPM and complementary strategies. Some strategies can include cultural methods; mechanical/physical methods; biological methods; and chemical methods to efficiently manage pest populations. So the farmer must understand the growth habits of the plant and its cropping system, knowledge of the biology, the plant growth stage or environmental conditions, accurate pest identification and type of damage caused by potential pests (Baxendale and Wright, n.d.).

2.4.1 Cultural method

Cultural controls are the oldest methods that have been used to manage pest populations and involve manipulating the environment to make it less suitable for pest survival. However, with the development of synthetic pesticides these controls were rapidly abandoned or de-emphasized and research on them was largely discontinued. Because cultural controls are preventative rather than curative they are dependent on long-range planning. Also, because they are dependent on detailed knowledge of the bio-ecology of the crop-pests-natural controls-environment relationships, most of which, in the past, were poorly understood the results were very variable, and it was often difficult to evaluate their effectiveness. There are many measures to be applied in cultural method, depending on real situation of litchi orchard, and surrounding factors to decide which measures should be applied.

2.4.1.1 Pruning and sanitation

Many insect and mite pests seek shelter or attempt to over-winter in plant residues. Over-wintering forms include eggs on dead leaves, adults in plant stems or under crop residues, and larvae or pupae in plant stems or in the soil. Removing dead branches or canes from trees and shrubs and raking and composting leaves, grasses and other plant debris helps eliminate many over-wintering sites (Pandey and Harish, 1998). Pruning can carry out several times a year, however the most important times is after fruit harvesting to promote growth and development of branches, twigs, shoots, and leaves (Tran, 1999). Pruning the fruit trees is important to prevent insect and disease pests from attacking and damaging. The pruned longan, mango, and orange orchards made the population of aphids decreased after pruning. The pruning also decreased canker and greening symptoms on orange trees after fertilizing due to open and clear the canopy. The pruned orchard would reduce total cost because of the reduction of pesticide use and labor cost. The pruned trees with good canopy also get more yield and quality. Besides those, the pruning will help to open the tree to improve air movement, light, and break down the shelters for insect pests. Pruning will allow chemical application easier access and may remove sources of infestation (Duong *et al*., 2002).

Sanitation during the growing season also can be important. It is necessary to reduce the initial population of the pest. Harvest fruits as they ripen. Over-ripe fruit may serve as breeding sites for fruit flies, picnic beetles, or houseflies, honeybees or other insects (He, 2000).

2.4.1.2 Cultivation

It is necessary to keep crop areas weed-free. Many weeds and other crops serve as a reservoir for insects such as leaf-feeding caterpillar, litchi stinkbug, leaf miners and aphids, which may later move to garden crops. Use fall and spring cultivation to incorporate compost or crop residues and expose soil-dwelling insects to natural enemies and the weather (Vu, 1996).

2.4.1.3 Variation in time of harvest

This strategy is aimed to regulate crop's growth stage that has the most resistance ability to the time the inset pest's attack and damage is heavy or planting the crop so that the most susceptible stage of crop occurs when the pest is least abundant. Similarly reductions in pest problems can be achieved by distributing actively and carefully harvest timing (Tran *et al.*, 1996).

2.4.1.4 Intercropping and rotation

Intercropping refers to planting two or more crops in adjacent plots to slow the spread of pests and to provide habitat for natural enemies. This practice provides some isolation of pest infestations and can reduce the spread of damaging pest populations. Also, isolated pest infestations are generally easier to manage. Companion planting involves growing certain types of plants to protect neighboring crops by repelling or confusing insect pests. Intercropping increased beneficial insect diversity. Combining crops with low similarity in pest complexes and different architecture may have the potential to attract greater numbers of beneficial insects as well as greater species richness (Wright and Hoffmann, 2001).

Crop rotation, especially an extended crop rotation using three or more crops, is an age-old sustainable farming practice capable of maintaining crop yields. Using Integrated Pest Management (IPM) may help lower your crop pest management input costs. Crop rotation is part of an IPM strategy designed to manage pest populations. Crop scouting to determine economic thresholds is another IPM strategy. Implementation of an extended crop rotation of three or more years is particularly helpful in breaking the developmental cycles of pests. Diversifying crops in an extended rotation changes the host plants of potential pests, which in turn disrupts the life cycles of plant diseases, insects and weeds. Rotations combined with a conservation tillage program—improves soil structure, which in turn increases soil organic matter and water infiltration rates. Soil with improved structure is more resistant to soil erosion. Keeping soil in the field instead of in streams, lakes and rivers helps improve surface water quality (Witt *et al.*, 2002).

Planting patterns and the diversity of plant species in orchard may influence natural enemies of various insect pests. A diversity of plants increases the likelihood that some of them will harbor low levels of pest insects, which allows predatory and parasitic insects to survive periods of low pest populations on other plants. Many predatory and parasitic insects feed on pollen, nectar or plant saps either as an essential part of their nutrition or as an alternative food source in the absence of prey insects. Having a diversity of flowering plants with different blooming periods can increase survival of many beneficial insects (Baxendale and Wright, n.d.).

2.4.1.5 Mulches and cover crops

Mulch has many effects on the pest and beneficial insect. Thick mulches of plant material will encourage the development of potentially damaging pests by residence or over-wintering. However, light mulch of straw or shredded plant material will conserve moisture and restrict habitat of the pests. Additionally, appling plant residues and compost in the fall and deeply tilling into the soil would make increase of the organic content of soils and help retain moisture and improve fertility.

Cover crops provide certain beneficial effects; they prevent weed growth, reduce insect pests' damage, and protect young trees from wind and even from cold. They are also a source of mulching after harvesting (Sauco and Menini, 1989).

2.4.2 Mechanical/physical method

Mechanical/physical pest control methods include hand removal; syringing or trapping devices. They are the oldest, and in some cases, the simplest of all insect control methods. These tactics differ from cultural control measures because they are directed against the pest itself rather than the pest's environment.

2.4.2.1 Hand removal

The litchi farmer in Vietnam applied much local knowledge to manage insect pests in their orchard. They always remove large or readily visible insects by hand and destroy, or dislodge pests into a can containing a small amount of water and detergent. The egg masses of many insects can be scraped off or smashed such as the egg of the litchi stinkbug. However hand removal requires considerable time, and may not be feasible for heavy infestations or larger landscapes or gardens (Le *et al.*, 2000).

2.4.2.2 Trapping

Various kinds of traps can be used to monitor insect abundance, and in some cases, help reduce pest numbers. Yellow sticky traps are highly attractive to whiteflies, aphids, thrips, leafhoppers and other small flying insects, and are used by some commercial greenhouses for insect control. In outdoor settings, traps placed near susceptible plants may capture some invading insects before they can damage the plant. Other trapping devices, used largely against fruit flies and caterpillars, use pheromones, insecticide baits or attractive scents to lure flying adult stages to their traps (Quangninh Service of Science, Technology, and Environment, 2002). They are considered to be monitoring tools rather than control measures.

2.4.3 Biological method

Natural control strategies that employ biological agents for pest suppression are generally classified as biological control methods. In conventional usage, this term usually refers to the practice of rearing and releasing natural enemies, including parasites, predators, or pathogens. A slightly broader understanding includes any related management activity that is designed to protect or conserve natural enemies. The beneficial species are common in most natural communities and, although their presence is often unnoticed, they help maintain the "balance of nature" by regulating the density of their host or prey population. Insect species often become "pests" when this ecological balance is disrupted from natural events or human intervention. Biological pest control strives to reestablish this balance by developing population of natural enemies. The key to biological pest control is effective combination of different control methods in an IPM program, which can suppress damage from all pests and diseases to below the economic threshold level. This often involves the use of chemical pesticides that are compatible with natural enemies. As a matter of fact, biological control is always effective against one pest, but the crops may suffer from other pests or plant diseases, which need to be controlled by chemicals (Maity and Mitra, 2001).

2.4.3.1 Beneficial insects and mites

Increasing dependency and overuse of pesticides have begun to pose serious problems such as pest resistance and resurgence. One important approach to reduce the application of pesticides is to take advantage of the natural enemies in the agroecosystem. Many natural enemies of the pest species have been identified from Thailand orchards, especially Hymenopteran parasitoids belonging to different families, e.g. Chalcididae, Braconidae, and Ichneumonidae. Predators are mainly spiders such as the predaceous bug, and different species of predaceous mites. This natural enemy complex can be expected to have a substantial influence on the reduction of pests, if the beneficial species can exist under appropriate conditions (Schuetz *et al.*, 2002).

Natural populations of predators (e.g., lady beetles, lacewings, syrphid flies, praying mantis, wasps, and predaceous mites) and parasites (e.g., parasitoid wasps and flies) are valuable in reducing infestations of insect and mite pests. If these or other beneficial organisms are observed near the garden, take care to insure their survival. If pest suppression becomes necessary, select control measures, which minimize injury to beneficial organisms, while still providing satisfactory control of the target pest. A low level of pest infestation may need to be tolerated to attract and maintain natural enemy populations. Density of beneficial organisms will fluctuate depending on that of pest population. As in the case of litchi stinkbug when taking attention to its parasites and parasites' fluctuation, number of this species' parasitized egg increases gradually from early season up to late season (Table 2.2). These numbers are 2.83% in early season and 93.49% in late season (Tran *et al.*, 1996).

In general, this approach is risky because success requires a detailed knowledge of predator/prey or parasite/host biology, accurate timing, and careful management. In the long run it is generally more practical to conserve naturally existing enemy populations through wise pest management practices.

Table 2.2 Proportion of parasitized litchi stinkbug egg in Hanoi region

Investigation time	Number of monitored egg	Number of parasitized egg	Proportion (%)
18 – 20, April	106	3	2.83
28 – 30, April	273	17	6.22
10 –15, May	246	230	93.49

Source: Tran *et al.*, 1996

In short, biological control methods can be used as part of an overall integrated pest management (IPM) program to reduce the legal, environmental, and public safety hazards of chemicals. In addition, it may be a more economical alternative to some insecticides. Some biological control measures can actually prevent economic damage to agricultural crops. Unlike most insecticides, biological controls are often very specific for a particular pest. Other helpful insects, animals, or people can go completely unaffected or disturbed by their use. There is less danger of impact on the environment and water quality.

Biological control takes more intensive management and planning. It can take more time; require more record keeping, more patience, and sometimes more education or training. Successful use of biological control requires a greater understanding of the biology of both the pest and its enemies. Many natural enemies are very susceptible to pesticides, and using them successfully in an IPM program takes great care. In some cases, biological control may be more costly than pesticides. Often, the results of using biological control are not as dramatic or quick as the results of pesticide use. Most natural enemies attack only specific types of insects - unlike broad-spectrum insecticides, which may kill a wide range of insects. So biological control often needs active participation by growers in monitoring pests and natural enemies. Predatory mites and other biological control agents should be applied early in the growing season, before pest populations have had time to build up to high levels. The same natural enemy that is effective against a smaller population of target pests may have no impact at all on a well-established population with a high population density.

2.4.4 Chemical method

Many important chemical control methods are available for pest suppression, including attractants, repellents, sterilants and growth regulators. Insecticide is considered as the most powerful tool available for controlling fast and effectively insect and mite pests. In many cases, they are the only practical method of reducing insect populations that have already reached threshold levels. Insecticides have rapid curative action in preventing pest damage and offer a wide range of properties, uses and application methods. They are relatively inexpensive, and may provide substantial financial or aesthetic benefits. However potential problems associated with insecticide use include the development of pest resistance, outbreaks of secondary pests, adverse effects on nontarget organisms including humans and beneficial insects, hazardous residues in our food supply, and ground water contamination.

2.4.4.1 Pyrethrins and organic pesticides

Pyrethrins are refined from natural pyrethrum, which is extracted from a species of chrysanthemum grown primarily in Kenya. Synthetic pyrethrins, called pyrethroids, are based on the chemical structure of natural pyrethrins, but are much more stable and do not break down as rapidly. Many formulations of pyrethrins have a synergist added to increase their efficacy. Pyrethrins provide rapid knockdown, but residual activity is brief. They must be used often if insects persist. These chemicals are effective against many insect pests, especially soft-bodied forms, since they kill by absorption through the insect's skin and are not effective against spider mites. Permethrin was one of the pyrethroid insecticides proved to control effectively on the litchi fruit borer (*Conopomorpha sinensis* Bradley). It is applied weekly, up to two weeks before harvest in litchi orchard in Asia (Menzel, 2002).

Bark beetle is a major insect pest in olive orchards in Spain. The use of deltamethrin to control the olive bark beetle presents a knock-down effect during the first dates after the treatment, however it also affected all functional groups in the orchard, parasitoids, predators and phytophagous; therefore, it is necessary to improve insecticide-application conditions. Different parasitoid families and especially parasitoids of *P. oleae*, main pest of the olive orchard, were severely affected. In relation to predators, the negative impact of this insecticide was more evident on ants, cantharids, coccinellids and mirids. The attractant, ethrel, appears to have a luring effect on phytophagous and predators, although this was not evident for parasitoids. This shows the utility of this type of "lure and kill" method in future strategies of integrated control against this pest (Rodriguez *et al*., 2003).

Litchi is subjected to substantial damage by a range of insect pests in Thailand. One of the major pests is the litchi fruit borer (*Conopomorpha sinensis* Brandley) and a number of caterpillars, which feed on the leaves, flowers or fruits. Under pressure of the pests, the litchi farmers controlled exclusively with chemical insecticides. The main insecticides applied in litchi orchards are monocrotophos and methyl parathion. Because the litchi farmers applied chemical insecticides, it was resulting in overusing and depending increasingly on the insecticides by litchi farmers (Schuetz *et al*., 2002).

Insecticides were the most among the pesticides applied in pest management practices among rice and rice - fish farmers in the Mekong Delta. Approximately 50% were insecticides, 25% were fungicides and 25% were herbicides. The main insecticides used were pyrethroids (42%) carbamates (23%) and cartap (19%). Non-IPM farmers used twice as many pesticides as IPM farmers. Their application frequency and the amount of active ingredient used were 2–3 times higher per crop, as compared to IPM farmers (Berg, 2001).

In short, natural and mainly synthesized pesticides are considered as a powerful tool to control insect pests in agricultural production up to now. Due to adverse impacts of synthesized pesticides on environment, and beneficial organisms, use of these products should take more attention and just apply when necessarily to prevent unexpected impacts.

2.5 Damage and development of the insect pests

There are up to 21 species of plants to be hosted for litchi stinkbug (*Tessaratoma papillosa* Drury), but primarily in litchi, and longan. They have only one generation annually and hibernate in the adult stage. The females mate more than twice, and mating takes a long time. Egg laying occurs 1-2 days after mating. Each female lays around 14 egg once and lays 5-10 times in its life. Almost of the eggs are laid on the back of leaves. In spring the over-wintered females are attracted to trees with new flowers and shoots. Adults and larvae feed on terminals by sucking, which may be killed, and also on flowers and fruits, causing these to fall. Adult of litchi stinkbug can move quickly from this tree to others by flying. They are able to choose favorable tree to deposit the egg. They always reproduce and develop profusely and vigorously in reproductive cycle of growth of the litchi. Its density can reach level from 0.9 to 1.0 litchi stinkbug per branch. Density of litchi stinkbug is low in old and stunted tree. Density of larva depends on real situation of the tree, in flowering and fruiting trees this density is 16.75 times to 20.66 times higher than the tree without flowering and fruiting. Despite chemical applications, up to 30 percent of fruits in commercial orchards are damaged by the litchi stinkbug (Tran *et al.*, 1996).

Fruit borer (*Conopomorpha sinensis* Bradley) has around 10 generations yearly. Egg is laid on the surface of the fruit. Larva is born in underside of the egg and carves immediately and directly into the seed of young fruit, this induces the fruit to fall down and make yield loss. When the seeds of the fruit are swelled and harder, larvae will feed the peduncle of the fruit and egesta in the peduncle make critical reduction of the fruit quality. When harvest of the fruit, the larvae can bore into the young shoots, main veins of the leaves, or the peduncle of flowers. These make the main vein of the leaves into brown colour, flowers, and young shoots are dried and dead (Ha and Duong, 2001).

Looper (*Acidalia lactea* B.) has around 4 generations yearly. The egg stage probably lasts about 5 days, the larval stage about 4 weeks and the pupa stage about 10 days. The 1st and 2 nd instars larvae always stay in the top of the canopy in diurnal time, and let silk from their mouth fall down around the canopy of the tree to diffuse to other trees by wind. Instar 1, larvae feed on the mesophyll inside the epidermis. Instar 2 and

3, larvae feed on the mesophyll and make the leaves full of holes. Instar 4, capacity to feed is increasing more; one larva can feed from 8 –12 leaves per day. Among 100 flushes were taken randomly, there were up to 50 leaves to be infested and have lost more than 30% of leaves. Besides the leaves, larvae can also feed on flower, and young fruit (Ha and Duong, 2001).

Fruit piercing moths have a proboscis that drills a neat hole in the skin of the fruit allowing them to suck the juice from the flesh. Contamination of the wound with yeasts and bacteria carried on the proboscis destroys the fruit. After a couple days, fermentation a mould development commences and the damage becomes readily appearent. The moths attack fruit during the last week or so prior to harvest (Menzel, 2002).

In short, in order to form and develop an effective strategy for managing insect and disease pests in the fruit orchard, the farmers should care of the characteristics as follows:

- Fruit trees are perennial, long life cycle. These make more chances for insect to attack, reproduce, and damage than a rice field, vegetable field, which are harvested and replanted each season.

- Specializing in the growing of fruit tree in long term will attract specific insect and disease pests, which attack a certain part of the tree such as flower, fruit, leave, etc. and damage seriously. On the contrary, intercropping or rotation will prevent these insect pests from damaging, but make more chance for the generalists to attack frequently.

- Fruit tree cultivation will make more condition and time for underground insect and nematodes to develop and damage.

- Fruit trees always have a dense canopy. This also will make more condition for the pests' residence and their damages. Besides these, the pests are also considered as an intermediate host to transmit virus, bacteria into the trees, which are very difficult to control.

However the fruit trees also have some strength as follows:

- Amount of fertilizers put down is always less than annual crops, so they are not rich in nutrient resource, which is distributed to a big tree in a long term in stead of concentration in short term for annual crops.

- The trees have enough time to defend by transforming toxins into non-toxins. So almost types of the fruit tree have capable to resist more enduringly to the pests' attacks.

- The trees have enough time and advantageous space for beneficial agents' development. This creates a necessary biological balance among insect species, restrains a certain pest's outbreak. This is a key factor for developing the strategy to manage fruit tree insect and disease pests.

- When insecticides are used in managing insect pests, we should be carefully selected and their application timed with respect to the developmental stages of both target pest and crop. Proper selection and timing of pesticide applications are extremely important in obtaining the best possible control with the least effect on the environment. It should always carefully measure pesticides and follow all label instructions (Tran, 1999).