CHAPTER VI

PRACTICES IN INSECT PEST MANAGEMENT

Litchi is crop that had a domestic origination, so they resist the insect pests rather well but it was only extensive cultivated litchi (Vu, 1996). However with changes in cultivation practices, from extensive farming into intensive farming that is applied a great amount of fertilizers, composition of pests, especially insect pests also change in more serious trend. So in order to cope suitably with the changes in composition, damage of the pests, the farmer also has changed practices in insect pest management to keep their fruits. The study concentrated on identifying and determining litchi insect pests, occurrence frequency, the most damaging insect pests, methods used for managing insect pests, as well as farmers' control practices.

6.1 Litchi insect pests

6.1.1 Composition of litchi insect pests

Identifying composition of insect pests is considered as an important step to apply reasonably methods to control them. When the composition of insect pests, major and minor insects is identified, after that identifying the methods to control the major insect pests and realizing gradually the potential minor insect pests. Because each insect species has different activity and damaging habit, insect pest management practices applied must also change to cope with them. The findings showed that there were up to 9 harmful insect species appearing and damaging on litchi orchards in both districts (Table 6.1).

These insect species belong to 5 different orders, including Coleoptera, Lepidoptera, Hemiptera, Neuroptera, and Homoptera (Nguyen, 2002). The species being under Coleoptera are big longicorn beetle, and small longicorn beetle. The species being under Homoptera are mealy bug, and wax scale. The species under Lepidoptera

are fruit piercing moths, looper, and fruit. The rest species are litchi stinkbug, and leaf-eating caterpillar being under Hemiptera and Neuroptera, respectively. Most of them damage leaf, flower, and fruit. However there were only some species to damage seriously in key phase of the litchi tree – reproductive phase.

Table 6.1 List of litchi insect pests in the surveyed farms

No.	English name	Scientific name	Order	Damaged part
1	Litchi stinkbug	*Tessaratoma papillosa* Drury	Hemiptera	Young leaf, flower, fruit
2	Mealy bug	*Aphis gressypoi* Glover	Homoptera	Young leaf, flower, fruit
3	Wax scale	*Ceroplastes ceriferus* A.	Homoptera	Young leaf, flower, fruit
4	Fruit borer	*Conopomorpha sinensis* Bradley	Lepidoptera	Fruit, shoot, leaf
5	Leaf eating caterpillar	*Parasa pseudorapanda* Hering	Neuroptera	Leaf, flower
6	Looper	*Scopula* sp.	Lepidoptera	Young leaf, fruit, flower
7	Fruit piercing moth	*Othreis fullonia* Clerck	Lepidoptera	Fruit
8	Big longicorn beetle	*Hypomoces squamosus* Fabricius	Coleoptera	Leaf, young fruit
9	Small longicorn beetle	*Platymycterus sieversi* Reitter	Coleoptera	Leaf, young fruit

Source: farmer interview, 2003

Among nine insect species, some of them were considered to be specialists and damage seriously on the litchi trees, including litchi stinkbug, fruit borer, and looper. Besides these, other minor insect pests are estimated as potential ones and can become more seriously in future such as fruit piercing moth, and wax scale. Besides mentioned insects, a series of other insects were also exposed in litchi orchards in Vietnam as well

as in the world. Over 58 species of pests have been reported damaging litchi trees in China. Of these the major pests are litchi stinkbug (*Tessaratoma papillosa* Drury), litchi longicorn beetle (*Hypomoces squamosus* Fabricius), litchi midge (*Dasineura* sp.), and erinose mite (*Aceria litchii* Keiffer) (Mitra, 2001). In thailand, Among insect pests a few are seriously threatening litchi growers. They are the fruit borer (*Conopomorpha sinensis* Bradley), longan-sucking bug (*Tessaratoma papillosa* Drury), fruit-piercing moth (*Othreis fullonia* Clerck), twig borer (*Zeuzera* sp.), and leaf miner (*Conopomorpha* sp.). Other insects occasionally threaten litchi, such as the leaf eating caterpillar (*Oxyodes* sp.), scale insects and mealy bugs. Even though they are not of much concern, the litchi rust mite (*Aceria litchii* Keiffer) or erinose mite can damage all newly flushed shoots of neglected trees (Sethpakdee, 2001).

In Vietnam there are also many authors studying on the rule of occurrence and development, damages and composition of litchi insect pests. Some most important insects damaged seriously on the litchi orchards in areas of Hanoi, Haihung, Namha, and Yenbai, include litchi stink bug, white scale, litchi piercing moth, and fruit borer (Tran *et al.*, 1996). In whole northern important litchi areas, there are up to 51 damaging species to be identified, in which popular insect pests are 11 species. There are only 9 species damage massively from flowering to harvest phase (Dao *et al.*, 2003).

6.1.2 Occurrence frequency

Identifying the time insect pests occur is very important to determine the methods and time to control them. One species can appear once or more a year. However the importance is the time to occur and damaging level. If most of them appear and damage at the same time or on the same part of the tree, it is easier to manage and control them, and vise versa. They would be considered as more importance if their occurrence and damage in the key phase of the litchi tree – reproductive cycle of growth phase. By combination of some published documents (Dao *et al.*, 2003; Nguyen, 2002), monthly occurrence frequency of litchi insect pests in litchi orchards was studied and established (Table 6.2).

Table 6.2 Monthly occurrence frequency of litchi insect pests

Insect pest	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
	→	← RCG →					← VCG					
Litchi stinkbug		x	x	x	x	x	x	x				
Mealy bug			x	x	x							
White scale		x	x	x	x							
Fruit borer				x	x	x	x					
Leaf eating caterpillar		x	x	x								
Looper			x	x	x		x	x	x	x	x	
Fruit piercing moth				x	x	x						
Big longicorn beetle				x	x				x	x		
Small longicorn beetle				x	x				x	x		
Litchi stem-end borer	x	x									x	x
Leaf miner									x	x	x	x
Litchi barking miner	x	x									x	x

Source: synthesized, 2003

Note: RCG: reproductive cycle of growth phase

VCG: vegetative cycle of growth phase

In general, there are 12 insect species occur and damage regularly on the litchi in Vietnam. However there are only 9 insect species appear and damage in the key phase of the litchi – reproductive cycle of growth phase between March and May such as litchi stinkbug, meanly bug, wax scale, fruit borer, looper and fruit piercing moth. Others appear in the vegetative cycle of growth phase such as litchi stem-end borer, leaf miner, and litchi barking miner. Most of them appear on the litchi one period only in the year such as litchi stinkbug, meanly bug, fruit borer, litchi stem-end borer, and litchi barking miner. Others appear more than one period a year such as big and small longicorn beetles, looper. So identification of the major insect pests in the litchi orchard is very important in insect pest control and management.

6.1.3 The most important insect pests

There are many insect pests in the litchi orchards in the surveyed farms, however only some of them are the serious ones. So identifying the most important insect pests is necessary to determine the strategies that should be drawn to control and cope with insect pests efficiently. So a scoring system was established to determine which pests were considered to be the most damaging (method was mentioned in section 3.4.3). There are only 6 insect species to be suggested for the scoring list by involved and related people (Table 6.3).

Table 6.3 Insect pests associated with litchi orchard in the two districts

Insect pest	Total score		Average score	
	Thanhha	Chilinh	Thanhha	Chilinh
Litchi stinkbug	147.8	153.2	3.8	3.8
Fruit borer	136.9	160.0	3.5	4.0
Looper	127.1	134.0	3.3	3.4
Fruit piercing moth	72.9	79.2	1.9	2.0
Wax scale	65.9	70.0	1.7	1.8
Mealy bug	69.8	77.2	1.8	1.9

Source: farmer interview, 2003

Respondents in both districts were asked to score the insect pests on a scale of from 1 to 5, with 1 signifying minor pests and 5 signifying major pests (Appendix Table 1). Among the insect pests, litchi stinkbug received the highest average score (3.8) in Thanhha district, but it was only the second average score in Chilinh district (3.8). Fruit borer got the second average score (3.5) in Thanhha district, and the highest average score in Chilinh district (4.0). Looper had the third average score in two districts, 3.3 and 3.4 in Thanhha and Chilinh districts, respectively. Other insect pests received the average score less than 2 that were considered as less importance in both districts. So the top three pests were litchi stinkbug, fruit borer, and looper. These scores were quite suitable with the litchi farmers' initial points.

However there are some differences among scorings of the top three insects, meanwhile the most important insect in Thanhha was litchi stinkbug, the second was fruit borer, and the last – looper. The order of the most important insects in Chilinh are the fruit borer – the most important, litchi stinkbug – the second, and looper – the third. There was the difference in the order of the most important insect pests by the difference between two systems, lowland and upland systems. The moth of fruit borer was fond of living and hibernating inside litchi crown, and bushy areas such as forest and warmer weather condition (Ha and Duong, 2001). Chilinh with hill, mountain, and bushy forest is considered to be more favorable area for fruit borer than Thanhha plain district to live, hibernate and damage on the litchi. The litchi stinkbug is able to live and damage in all areas in Vietnam. It is considered to be common pest on both litchi and longan (Tran, 1999). Looper is a pest that damage on young leaves, flower, and young fruit.

6.1.4 Description of some major insect pests

Litchi tree, like other crops, has many insect pests to appear and damage. However not that all of them are major insect pests, only some of them are major insect pests, others are minor pests. So the problem how to be aware of the major insect pests from the minor insect pests is very important to determine measures to control suitably and effectively. This is considered as first and basic knowledge of the grower in insect pest management. If they can not identify the major insect pests in their orchard, this means that insect pest management would be failed. So it is necessary to identify and describe the major insect pests in litchi orchards. By combination between survey and published books (Le *et al.*, 2000; Ha and Duong, 2001), the results were shown in Table 6.4.

Table 6.4 Description of some major insect pests

Phase	Description
Egg	- Litchi stinkbug: white-green, laid into hatch, on backside of the leaf, on the bunch of flower, each hatch from 13-14 eggs (Plate 6.2). - Fruit borer: flat round, unseen by naked eye, laid on fruit dispersedly. - Looper: oval, green, laid into hatch on the leaf, each hatch consists of above 100 eggs covered by yellow-grey hair.
Larvae	- Litchi stinkbug: coexistence in instar 1 and 2, grey. Scatter in instar 4 and 5, scarlet (Plate 6.1). - Fruit borer: flat round, tubular, yellow-white, and live inside the fruit (Plate 6.7). - Looper: green in instar 1 and 2, the color changed depending on surrounding circumstance from instar 4 (Plate 6.4).
Pupa	- Fruit borer: enclosed pupa, tubular. Pupate inside the rolled leaf. - Looper: bare pupa, black-grey. Pupate in the soil (Plate 6.5).
Adult	- Litchi stinkbug: brown-yellow, length of 20-25 cm, width of 12-15 cm; a coat of white wax in stomach (Plate 6.3). - Fruit borer: small, and grey. Wing length of 5-6 cm (Plate 6.8). - Looper: brown-grey, but yellow in stomach (Plate 6.6).

Source: survey, 2003; Duong, 1996

From the description and plates, it is easy to be aware that each insect pest has a different formation. Phases of the litchi stinkbug are relatively easy to monitor and identify by naked eye. Larvae live in a group from age 1 to age 2 and egg is deposited into a hatch, so application of control practices would more advantage. The looper larva is more difficult to identify by its change depending on the surrounding circumstance, especially in age 5 and age 6. The fruit borer larva is almost not able to monitor, and identify because they bore and live inside the fruit.

Plate 6.1 Litchi stinkbug – larva

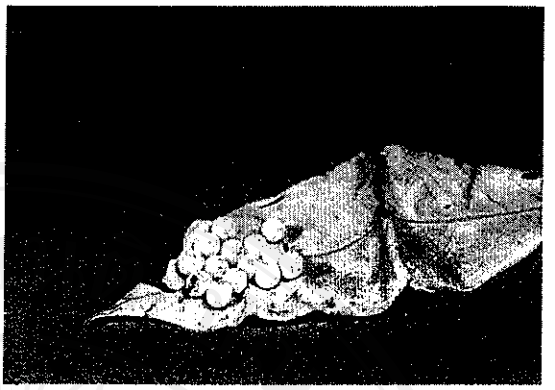

Plate 6.2 Litchi stinkbug – egg

Plate 6.3 Litchi stinkbug – adult

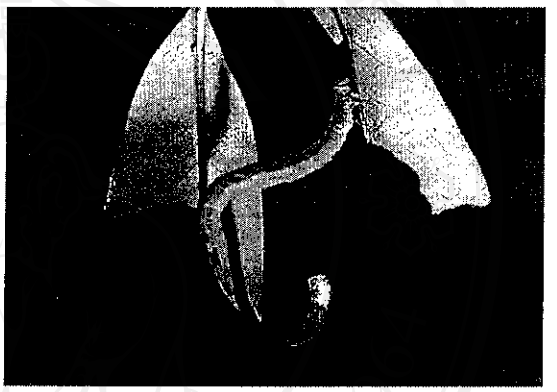

Plate 6.4 Looper – larva

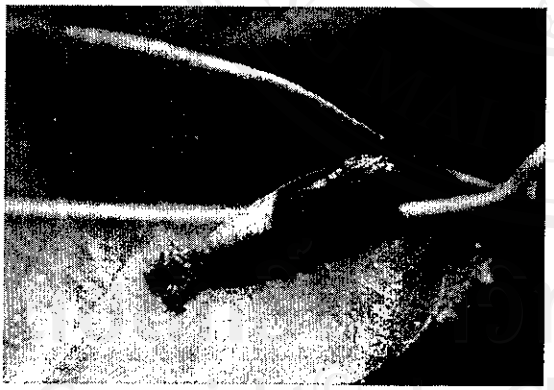

Plate 6.5 Looper – pupae

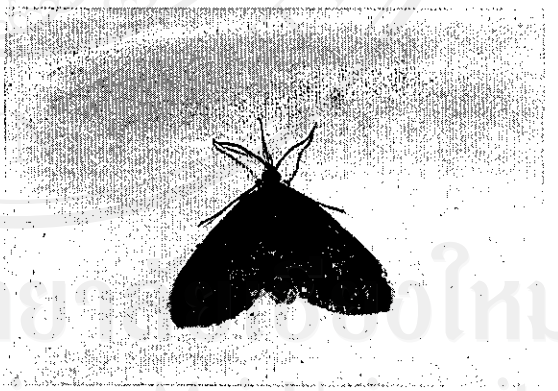

Plate 6.6 Looper – moth

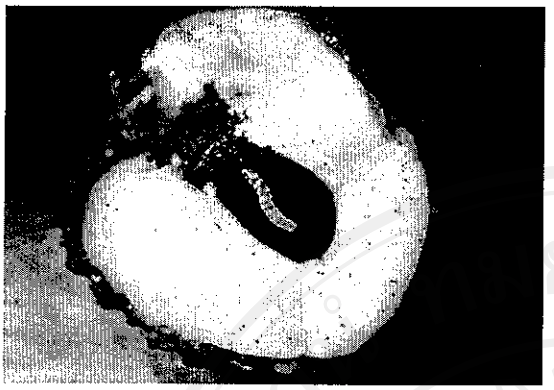

Plate 6.7 Litchi fruit borer – larva

Plate 6.8 Litchi fruit borer – moth

Besides identification of the major insect pests through the description and the plates, symptom of the major insect pests on the litchi tree is necessary to be aware. This is very significant in combination with identification of the major insect pests to identify the major insect pests more quickly and exactly. The results of the symptom s of the major insect pests were shown in Table 6.5.

Table 6.5 Damaging symptom of the major insect pests

Insect pest	Description
Litchi stinkbug	Larva and adult suck the young fruit, young shoot and make them stunt, dead, and dropping.
Fruit borer	Bored leaf and shoot are stunt, less development and dead. Bored fruit has feces pushed out of the fruit. One larva can bore from 2 to 3 fruits.
Looper	Larva feeds young leaf, make the leaf full of holes. One larva can feed 8 to 12 leaves/day

Source: survey, 2003; Duong, 1996

6.1.5 Fluctuation of insect pests

To understand more clearly about the most serious insect pests, rule of occurrence and damage of the top three insects, fluctuations of them were monitored in Spring-summer litchi season, 2003. The study of the fluctuation of the insect pests has an utmost important significance in estimating and forecasting tasks about appearance and development. When having the fluctuation, the litchi farmers as well as forecasters

could take positively methods to prevent or control them. The findings were shown in Figure 6.1 and Appendix Table 2.

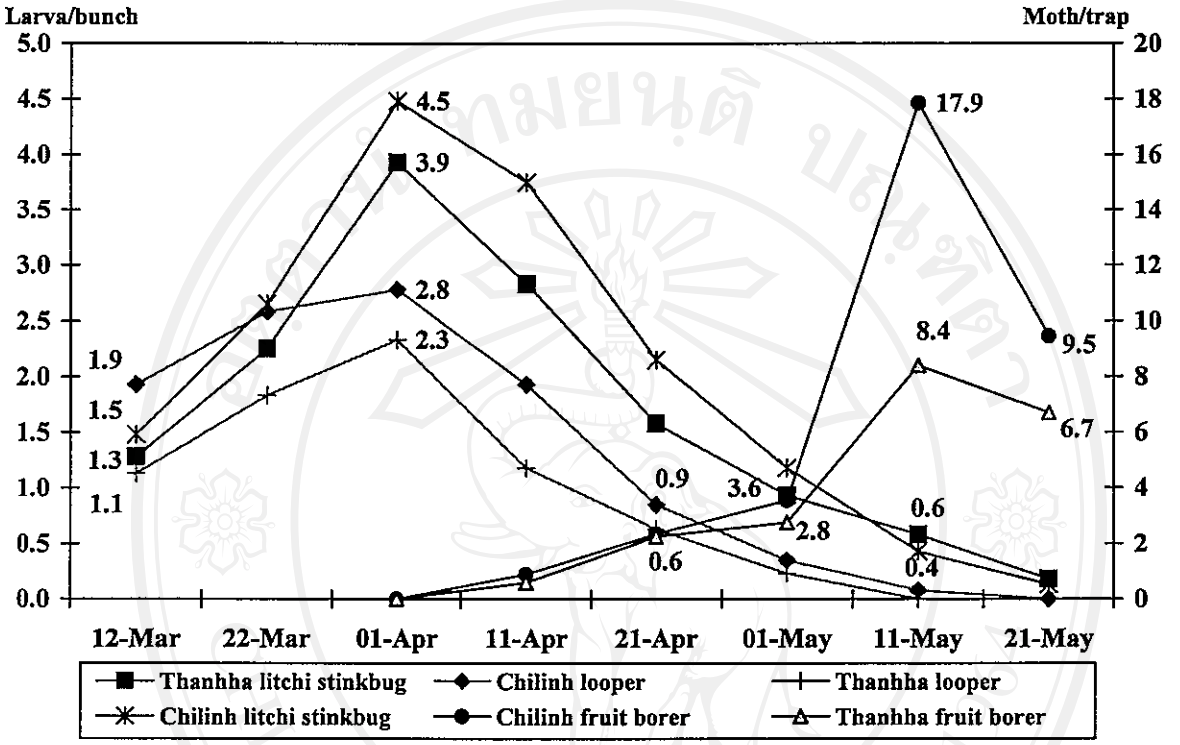

Figure 6.1 Fluctuation of top three insect pests in the surveyed areas

It seems that the insects occurred more early and damaged more seriously in Chilinh than those in Thanhhha district. Litchi stinkbug was at peak on April 1 with 3.9 insects/bunch and 4.5 insects/bunch in Thanhha and Chilinh districts, respectively. This was the time young fruits have just set. Soon after this peak, the density of the litchi stinkbug declined in both districts with the density of 0.18 and 0.13 insects/bunch on the last date of investigation, May 21. Like litchi stinkbug, the litchi looper was also at peak on April 1, with the density of 2.3 and 2.8 larvae/bunch in Thanhha and Chilinh districts, respectively. However the density of the looper declined more quickly in both districts because source of food such as young leaf, fruit, and flower was running out. So it was not able to look for any looper in the both districts on May 11 in Thanhha and on May 21 in Chilinh district.

In case of the fruit borer, however investigation dates are in progress paralleling with the litchi stinkbug and the looper, but the fruit borer had just found on April 11 with density of 0.6 and 0.9 moths/trap in Thanhha and Chilinh districts, respectively. The main reason for this late occurrence is that the fruit borers just occur and damage on the young fruit forward up to two weeks before harvesting (Le *et al.*, 2000). These densities increased up strongly over investigation dates and at peak on May 11 with a density of 8.4 and 17.9 moths/trap in Thanhha and Chilinh districts, respectively. After May 11, the density declined and reached down 6.7 and 9.5 moths/trap on May 21 in Thanhha and Chilinh districts, respectively.

In general, occurrence and damage of the top three insects were suitable with their rules. As in the case of the fruit borer, this species was at peak in May 14, 2001 with 10.4 moths/trap with investigation interval of 10 days (Dao *et al.*, 2003). This means that the litchi stinkbug and the looper would occur and damage seriously and mainly on the phase from flowering to fruit set that nutrient source are suitable and abundant (Dao *et al.*, 2003). The litchi stinkbug is always at peak at the time around 10 – 15 days after fruit set, meanwhile the fruit borer is always at peak at the time 15 – 20 days before ripen (Bacgiang sub-department of plant protection, 2003).

However there were the differences in law of occurrence and damage of the top three insect pests between two systems, upland and lowland systems. All top three insect pests occurred more abundantly in Chilinh district than that of Thanhha district. These take place by following reasons:

- By surrounding environment for hibernant moths: if surrounding environment is bushy, it is more chances for the moths to hibernate and damage (Bacgiang sub-department of plant protection, 2003). Adjacent environment of the litchi cultivation area in Chilinh district is bushy and forest trees, meanwhile it is clear in Thanhha district. So Chilinh environment is much more favorable for hibernant moth. This results in source of insect for next season in Chilinh district is more abundant than that in Thanhha district.

- Environment in the litchi orchards: where microclimate is warmer in winter, the insect pests would hibernate much more (Bacgiang sub-department of plant

protection, 2003). Environment in the litchi orchards in Chilinh district was warmer than that of Thanhha district, so it was also more favorable for the insect to hibernate. Chilinh district has a range of mountains and vast and bushy forest areas in northern side, so they have an effect on wind power in the winter and regulate temperature better. On the contrary, besides the litchi orchards, Thanhha district has completely bald surrounding area.

6.2 Practices in the insect pest management

Up to now, pest control method by insecticide application is generally considered as a indispensable one in insect pest management in agricultural production, and in litchi production particularly. Besides application of insecticides, the litchi farmers also applied many other practices such as application of pruning, or hand removal to control these pests.

6.2.1 Methods applied

Nowadays, in model of intensive farming most farmers heavily rely on pesticides to control the pests. Besides use of the pesticides, the farmers always apply many traditional ways such as hand removal, pruning to reduce damages of pest population at the lowest possible level. Application of insecticides is considered as an indispensable tool in the farmer's insect pest management because they could act fast and stamp out the pests' outbreak in a short time. Besides insecticide method, the litchi farmers also applied many other methods or their own local knowledge in insect pest management in order to improve control effectiveness. The findings in two systems were showed in Table 6.6.

There were up to 100% of the surveyed households who apply insecticides to control the insects in both districts. However the litchi farmers also apply several other methods to control the insects besides the pesticides. There were up to 82.1% and 62.5% of the surveyed households applied pruning and considered the pruning as an insect management method in Thanhha and Chilinh districts, respectively.

Table 6.6 Distribution of households used different control methods

Method	Thanhha		Chilinh	
	No. of farm	Percent	No. of farm	Percent
Insecticide	39	100.0	40	100.0
Pruning	32	82.1	25	62.5
Removal	22	56.4	21	53.9

Source: farmer interview, 2003

Besides the pruning, the litchi farmers also applied another method to manage the insect pests in the litchi orchards – hand removal method. Nevertheless application rate of the litchi farmers was not as high in the hand removal methods as that of the pruning method. According to the findings, the removal method had 56.4% and 53.9% of the litchi farmers to apply in Thanhha and Chilinh districts, respectively. However the hand removal methods can't apply for every type of insect because of its limitation, the growers said. In case of the fruit borer, the larvae of this insect are very small and live only inside the fruit, so the "removal" method can't apply for the fruit borer.

6.2.2 Practices applied

There were up to three methods applied in litchi orchards in both litchi production systems. However practices applied in each method were quite different, the finding was shown in Table 6.7.

So practice in insecticide method was spraying only, the farmers mixed the insecticide with water into a spraying solution to spray directly on the tree. Practice in the pruning method applied was pruning and cleaning up the tree residues that are breakage, bushy and infected by insects and diseases. Many farmers in both systems applied this method. They were aware of importance of the pruning in improving more yield and fruit quality, air movement, light, and break down the shelters for insect pests, allow chemical application easier access and remove sources of infestation. Practices in the hand removal included capture by urine application, capture of hibernant litchi stinkbug, application of soil trap, catching, picking down and killing the larvae and

hatches. These practices applied generously among the growers in both districts, because they are easy to apply by hand.

Table 6.7 Practices applied in insect pest management in both districts

Method	Practice
Insecticide	Application of insecticide by spraying only
Pruning	Pruning and cleaning up the tree residues that are breakage, bushy and infected by insects and diseases
Hand removal	Capture by urine application
	Capture of hibernant litchi stinkbug
	Application of soil trap
	Catching, picking down and killing the larvae and hatches

Source: farmer interview, 2003

6.2.3 Insecticide practice

6.2.3.1 Insecticides applied

Application of insecticide is considered to be an utmost important method for the litchi farmers in controlling the insect pests, because it helps the litchi farmers to prevent and control from insects' damages in the litchi orchards. The findings showed that (Table 6.8) the growers in both districts employed many insecticides to control the insect pests. There were up to 5 common names comprising of 24 trade names applied into the litchi orchards in the two systems (Appendix Table 3). Two of 5 common names are under the chemical family of the Pyrethroid (14 trade names), cypermethrin and alpha-cypermethrin; the rests, including dimethoate (6 trade names), fipronil (1 trade names), and cartap (3 trade names) are under the chemical family of the Organophosphorous, Phenylpyrazole, and Carbamate, respectively. All of them belong to toxicity class II that is signified by a yellow band and the word - toxic. Among above insecticides, the litchi growers applied cypermethrin the most – 8 common names. Among the popular insecticides under this family, including alpha-cypermethrin,

cypermethrin, deltamethrin, and permethrin, cypermethrin is considered as a high purity, strongest acting insecticide on the insect pests, and to be easy to manufacture, pack, store, and apply (Anon., 1998).

Table 6.8 Applied insecticides and their characteristics

Common name	Number of product	Chemical family	Toxicity class	PHI (days)	DT_{50} (days)
Cypermethrin	8	Pyrethroid	II	7	30
Alpha-cypermethrin	6	Pyrethroid	II	7	28
Dimethoate	6	Organophosphorus	II	21	16
Fipronil	1	Phenylpyrazole	II	21	122
Cartap	3	Carbamate	II	21	68

Source: farmer interview, 2003

Because the reasons mentioned above, the growers chose cypermethrin the most to control the pests. According to the growers, in order to choose a reasonable insecticide for controlling the insect pests, some steps should be included as follows:

- Firstly that is information from the media, recommendations of manufacturer and retailer. Then that is information on the label of the insecticide's bottle about which insect pest is the target to control. Continuously that is the efficacy on the insect pests when applying. And the last that is the price, low or high price.

6.2.3.2 Safety of the insecticide

This is a factor that affects on the environment unexpectedly. Insecticides when sprayed, a part would have an effect on the insect pests, the rest would disperse to surrounding environment, air, water, and soil environment. This would have negative effects on human, beneficial and soil organisms. These effects strong or light depend on each type of insecticide. The findings on safety of the insecticide are shown in Table 6.8. Pyrethroids are insecticides having negative effects on beneficial organisms; meanwhile Phenylpyrazole, Organophosphorous and Cacbarmate have slightly negative effects on the beneficial organisms. In terms of the insecticides' PHI and DT_{50} (PHI is

the index that show on the label of each insecticide bottle about pre-harvest interval. If the shorter PHI is, the safer for the customer insecticide is; DT_{50} is the index on environment. It means that the time that chemical to be degraded up its 50% in soil environment) (Duong, 1996), all litchi farmers applied fipronil and cartap only in the last stage of fruit to control fruit borer. Although PHI of the two insecticides are very long – 21 days, the growers still applied these chemicals to control the fruit borer, even two weeks before harvesting. Majority of farmers (> 80%) understand that the pesticides cause the problem for the health, but most of them (> 95%) are unaware about the environmental drawbacks of the pesticides, as well as negative impacts of the pesticides on the yield (Berg, 2001). DT_{50} of these two insecticides are very different, 122 days for fipronil and 68 days for cartap. However cartap must applied with a dose 25-folds higher than fipronil. So cartap's impacts on environment are stronger than that of fipronil. Dimethoate is an insecticide belonging to Organophosphorus family name. It is safer for non-target organisms and a DT_{50} very short, 16 days only, however it is relatively harmful to warm blood animals (Duong, 1996).

6.2.3.3 Insecticide's impacts on insect pests

Among the 5 common names, two of them are under Pyrethroids, which affect on the insects by contact poison (through insect skin) and stomach poison (a small amount of insecticides ingested by the insects). These Pyrethroids have a strong effect on the insect by contact method and safer for environment. However their shortcomings are making the resurgence of pest populations after decimation of the natural enemies, development of insecticide-resistant populations, and negative impacts on non-target organisms within and outside the crop system (Duong, 1996). The remaining three common names affect on the insects by 2 methods, they are contact one, and systemic one (the insecticides will be absorbed by the crops and go inside and up to shoots and leaves. The insects are killed when sucking the sap). These insecticides are considered as an effective tool to control sucking insects and borer. Besides the shortcomings of the pyrethroids mentioned above, these insecticides have a negative effect on environment and require a longer PHI. However in some cases, they are safer for non-target organisms than the pyrethroids (Duong, 1996).

In brief, the application of these insecticides in Vietnam, especially in areas of litchi cultivation is dangerous for environment, non-target organisms, and human, especially insect pests' resistance to the insecticides.

6.2.3.4 Spectrum of the insecticides

Up to now Vietnam farmers are inheriting a series of pesticide trade names that are easy to be confused in application. However the problem is the insecticides bought by the litchi farmers have an effect on the litchi insects or not. To solve this, spectrum of insecticides used to control insect pests in surveyed farms was synthesized (Table 6.9).

Table 6.9 Spectrum of applied insecticides

Common name	Effective on	Dosage
Cypermethrin	Stink bug, aphids, wax scale, leaf eaters, leaf miner, moths	1:1,200 (25%)
Alpha-cypermethrin	Stink bug, aphids, wax scale, leaf eaters, leaf miner, moths	1:1,200 (5%)
Dimethoate	Stink bug, aphids, wax scale, leaf eaters, leaf and barking miners, moths	1:480 (40%)
Fipronil	Fruit and stem-end borers, barking and leaf miners, stink bug, aphids, wax scale, leaf eaters, moths	1:12,000 (80%)
Cartap	Fruit and stem-end borers, barking and leaf miners, stink bug, aphids, wax scale, leaf eaters, moths	1:480 (95%)

Source: survey, 2003; Duong, 1996

The findings show that all of the insecticides bought by the litchi farmers have an effect on the litchi insects with recommended dosages. Spectrum of these insecticides is very broad. They could kill most of the insects, both harmful and beneficial insects in the litchi orchards. However the insecticides with highest

effectiveness on stinkbug and looper are cypermethrin, alpha-cypermethrin, and dimethoate with dosage rate of 1:1,200; 1:1,200; 1:480, respectively. Fipronil and cartap have a higher effectiveness on fruit borers than others with dosage rate of 1:12,000 and 1:480, respectively.

In general, the litchi farmers in both districts have known of which insecticide is suitable to apply for which insect. However this is only two of 4 procedures to apply correctly pesticides, the time and dose to apply these insecticides are a completely problem.

6.2.3.5 Application frequency

Frequency of insecticide application depends much on the litchi farmers' knowledge, weather, insect's pressure, etc, so identifying number of time to apply is very important to suppress the insect pests successfully and to keep income highest and costs lowest. The point of departure from this, frequency of insecticide application was studied (Table 6.10) to make more clear the practices in insect pest management as well as in insecticide application in both districts.

Table 6.10 Frequency of insecticide application in the two districts

Insect pest	District	Average	Min	Max	SD
		....No. of application time....			
Litchi stinkbug	Thanhha	2.7	2.00	4.0	0.6
	Chilinh	3.0	2.0	5.0	0.7
Fruit borer	Thanhha	2.0	1.0	3.0	0.6
	Chilinh	2.4	1.0	4.0	0.6
Looper	Thanhha	1.9	1.0	3.0	0.5
	Chilinh	2.1	1.0	3.0	0.7
Overall	Thanhha	6.6	4.0	9.0	1.1
	Chilinh	7.4	5.0	10.0	1.4

Source: farmer interview, 2003

The results showed that number of application time was quite different between two districts. Annually total numbers of application in the litchi orchards were 6.6 times in Thanhha district with a variation from 4 up to 9 times and a standard deviation of 1.1. Meanwhile these were 7.4 times with a variation from 5 times up to 10 times and a standard deviation of 1.4 in Chilinh district. These application times for each insect pest were also quite difference between two districts. The litchi farmers in Chilinh sprayed up to 3.0, 2.4, and 2.1 times to control the litchi stinkbug, the fruit borer, and the looper, respectively. Meanwhile these numbers were fewer in Thanhha district with 2.7, 2.0, and 1.9 times for the litchi stink bug, the fruit borer, and the looper, respectively.

Among these top three insect pests, number of application time was quite difference. The highest number of application times were litchi stinkbug, the second was fruit borer, and last – looper. The main reasons for the difference among three insect pests' application times were the difference in period of time, and damaging level. The litchi stinkbug damages in a long time and seriously, fruit borer had the period of damaging time shorter than the looper, but its damaging level was more serious than the looper and more difficult to control than the looper. So the fruit borer's application times were much more than the looper one. In terms of difference in total application times, there are several reasons resulting in differences in total numbers of application times between two districts as follows:

- Chilinh district has more favorable environment for the insect pests to hibernate, develop and damage than that of Thanhha district (Section 6.1.5).

In general, most the litchi farmers sprayed the insecticides basing on their experience and periodicity. These were resulting in very high number of application times. If the spraying bases on the protocol provided by the district stations of plant protection, number of application times varied only from 5 to 6 times/year (Thanhha plant protection station, 2003; Chilinh plant protection station, 2003).

6.2.3.6 Application rate

As mentioned, the litchi farmers in both districts know which insecticide is suitable to apply for the target insect pests (Table 6.9). However the main difference problem was application dose – high, low or recommended. If reasonable low rate is applied, it suppresses not only the pests effectively but also saves more cost, protect the beneficial insects and environment. From this issue, basing on the dosage the litchi farmers applied and recommended by manufacturer on the label, a ratio between the litchi farmers' dosage and the recommended dosage was identified to consider how dosage the litchi farmers applied (Table 6.11).

Table 6.11 Application rate of the insecticides in the two districts

Common name	District	No. of farm	Farmer dosage	Recommendation dosage	Ratio
			.....ml/10-liter tank.....		
Cypermethrin	Thanhha	23	14.41 ± 3.04	10.00	1.44
	Chilinh	25	14.10 ± 2.71	10.00	1.41
Alpha-	Thanhha	24	14.96 ± 2.62	10.00	1.50
cypermethrin	Chilinh	23	14.75 ± 2.50	10.00	1.48
Dimethoate	Thanhha	13	31.35 ± 3.00	25.00	1.25
	Chilinh	16	31.41 ± 2.23	25.00	1.26
Fipronil	Thanhha	27	1.20 ± 0.15	1.00	1.20
	Chilinh	21	1.22 ± 0.13	1.00	1.22
Cartap	Thanhha	12	29.25 ± 3.26	25.00	1.17
	Chilinh	19	29.74 ± 2.62	25.00	1.19

Source: farmer interview, 2003

The results showed that all of the litchi farmers in both districts were applied insecticides exceeding recommended dosages. Overdose application took place mainly in the case of the alpha-cypermethrin with ratio of 1.50 times in Thanhha district and 1.48 times in Chilinh district. Continuously that was cypermethrin, dosage applied was

quite high. The ratios were 1.44 times higher in Thanhha district and 1.41 times higher in Chilinh district. Insecticides with little overdose application were the fipronil with the ratio of 1.20 and 1.22 times higher and the cartap with rate of 1.17 and 1.19 times higher in Thanhha and Chilinh districts, respectively.

In general, the litchi farmers in both districts applied overdose to control the insect pests in the litchi orchards. Three main reasons for this include as follows:

- The litchi farmers always think that if they apply overdose, controlling effectiveness will be higher despite without resistance of the insect pests.
- The litchi farmers did not change the chemical families in process of application resulting in the resistance of the insect pests.
- The insect pests have resisted to the insecticides increasingly, so the litchi farmers must apply overdose to control them more effectively.

6.2.3.7 Insecticide effectiveness

Insecticide is a powerful tool for controlling insect pests of litchi. Their major advantage is to have fast acting to kill and stamp out the insect pests' damages and outbreak. Key disadvantages of insecticides are costly, high toxicity and adverse effects on non-target organisms in the crop and nearby areas. From a litchi insect pest management standpoint, cost and killing natural enemies are of most concern. So insecticides should be applied in the proper amounts only when insect pest is abundance and its damages exceed the economic injury level if not suppressed. In order to understand more clearly about the insecticide and its importance as well as role in controlling the insect pests, the litchi growers were asked to estimate the insecticide's control effectiveness as well as other methods on each the top three insect pests (Table 6.12).

The findings showed that application of the insecticides give comparatively high efficacy on the top three insect pests. The highest efficacy of the insecticides for the litchi stinkbug was 94.3% and 92.7% in Thanhha and Chilinh districts, respectively. The second highest efficacy was for the looper was 93.8% for the litchi farmers in

Thanhha district and 93.4% in Chilinh district. For the fruit borer effectiveness was 91.5% for Thanhha district and 88.3% for Chilinh district.

Table 6.12 Effectiveness of control methods estimated in the two districts

Insect pest	District	Insecticide	Pruning	Removal
		..... %		
Litchi stinkbug	Thanhha	94.3 ± 3.0	12.8 ± 6.2	5.9 ± 1.9
	Chilinh	92.7 ± 4.2	10.4 ± 5.2	5.4 ± 1.8
Fruit borer	Thanhha	91.5 ± 4.2	19.5 ± 6.1	n.a.
	Chilinh	88.3 ± 7.2	15.4 ± 6.0	n.a.
Looper	Thanhha	93.8 ± 2.5	4.8 ± 2.1	8.8 ± 3.0
	Chilinh	93.4 ± 3.4	3.7 ± 2.1	7.7 ± 3.1

Source: farmer interview, 2003

By and large, the insecticides contribute positively to control the insect pests in both districts. It is considered as an indispensable tool to control the insect pests in the litchi orchards in both districts. However, in the case of the fruit borer, insecticides applied in Thanhha district gave a higher efficacy than that in Chilinh district. Generally the insecticides had lower efficacy on the fruit borer than that of other insects, because activity characteristic of the fruit borer that made reduce efficacy of the insecticides on it (Table 6.4). When hatching, larvae bore immediately inside the fruit, so only systemic insecticides could give a high efficacy on them, however these could not also give as high efficacy as other insects. In terms of the minor insect pests, although they were not included to apply the methods to control, application of the insecticides on the main insects also gave the high effectiveness on the minor insects by chance.

6.2.3.8 Yield loss

Pest management is very important in crop production. Even after spending approximately 34% of variable crop production costs on pest control, farmers lose 10 to 30% of potential yield because of insects, diseases and weeds (Runyan and Wright, n.d.). In order to stress more damages of the insect pests in the litchi orchards, it is

necessary to estimate how many percent the litchi pests could damage to the litchi production if uncontrolled. Respondents were asked about the yield loss causing by the insect pests in the case of uncontrolled. The findings are expressed in Table 6.13.

Table 6.13 Farmers estimation of the yield loss if uncontrolled in the two districts

Insect pest	District	Average	Min	Max	SD
		.....%.....			
Litchi stinkbug	Thanhha	49.0	15.0	80.0	18.2
	Chilinh	54.3	15.0	85.0	16.7
Fruit borer	Thanhha	26.6	5.0	45.0	10.2
	Chilinh	42.3	15.0	75.0	13.5
Looper	Thanhha	17.6	5.0	35.0	8.1
	Chilinh	18.3	5.0	45.0	8.7

Source: farmer interview, 2003

The damaging rates of top three important insects were completely different. If uncontrolled, the stinkbug could damage and reduce yield at an average rate of 49.0% with a variation from 15.0 to 80.0% in Thanhha district and this average rate was 54.3% with a range between 15.0 and 85.0% in Chilinh district. Meanwhile the fruit borer could make losses yield from 5.0 to 45.0% with an average rate of 26.6% in Thanhha district and from 15.0% to 75.0% with an average rate of up to 42.3% in Chilinh district. The looper could cause a lower loss rate than the litchi stinkbug and the fruit borer. However the loss rate was also from 5.0 to 35.0% with an average of 17.6% in Thanhha district and from 5.0 to 45.0% with an average of 18.3% in Chilinh district.

In general, the litchi stinkbug was considered to damage and reduce the yield most to the litchi orchards in the both districts. However the litchi orchards in Chilinh were damaged more strongly and lost more heavily than that in Thanhha district. The main reasons for the yield loss as follows:

- Chilinh district has more favorable environment for the insect pests to hibernate, develop and damage than that of Thanhha district (Section 6.1.5). So rate of yield loss in Chilinh district were higher than that of Thanhha district.

6.2.4 Pruning practice

Pruning is a method very significant for insect pest management. Firstly, pruning help the tree growing better and then improve health to prevent pests from damaging on tree growth. Then pruning would support to remove infested parts of the tree out, break out residential environment of the pests and reduce significantly pests' damages to the tree. Nowadays the pruning is one of crucial components of the cultural method to prevent pests and reduce cost for controlling pests significantly (Nghe and Ngo, 1991). The findings showed that the pruning contributed a considerable part to prevent the insect pests' damages. On average, the growers pruned 1.9 and 1.7 times annually in Thanhha and Chilinh districts, respectively. The pruning brought about an average effective rate of 12.8% and 10.4% for preventing the litchi stinkbug from the damage in Thanhha and Chilinh districts, respectively. This effectiveness was 19.5% and 15.4% for the fruit borers in Thanhha and Chilinh districts, respectively - the highest efficacy among the top three insect pests. The pruning gave the lowest effectiveness on the looper with 4.8% and 3.7% in Thanhha and Chilinh districts, respectively (Table 6.12).

As known, the pruning would give the effectiveness in most the phase of the insect pests, especially the phase after the damaging period and hibernation. Adults of the litchi stinkbug would stop the activities after August, and hibernate on the bushy parts of the tree canopy and other areas (Tran, 1999). The pruning would break up the environment for the litchi stinkbug's hibernation and they would be killed. However effectiveness of the pruning on the litchi stinkbug was not so high as the fruit borer, because the adults of the litchi stinkbug hibernate not only on the tree but also in other areas. Moreover when pruning, the adult don't attached closely in litchi leaves like the fruit borer, they can drop down automatically, so collection and killing of this insect would be more difficult than the fruit borer. In the case of the litchi fruit borer, larvae employed the litchi or other tree leaves to roll into the nest, pupate inside and exist on the tree. So the pruning would give the controlling efficacy higher than other insects. The pruning had very little effectiveness on the looper. The pruning had some impacts on the looper by breaking the favorable environment for the generations' occurrence and damage in March and April; June and July; August and September.

In Vietnam, the litchi farmers always prune the tree around two times a year, autumn and winter pruning. Autumn pruning is carried out around one month after harvesting; winter pruning takes place on late winter or very early spring before budding or flower bud. Besides those, spring pruning is also implemented but irregularly and non-popularly. It always takes place after fruit set around 15 - 20 days.

- Bearing young trees: light pruning, maintenance of many branches and twigs. Generally it should only prune the branches and twigs that are not able to photosynthesize, low-lying branches, and pest infected branches.

- Business trees: the pruning should be heavier than the bearing young tree to focus the nutrients to the remaining branches, maximum reduction of pest source reside inside the tree, promote autumn buds to give the fruit next year.

Pruning can be light or heavy depending on the purpose. Light pruning means that only small part of the branches is pruned. This makes increase of the twigs and makes more chance to form new branches for the tree. Heavy pruning means that the whole branches or twigs would be pruned; the point to chop is the crotch of those branches or twigs (Le *et al.*, 2000).

Main purpose of the pruning is to help twigs and branches to be distributed equally, symmetrically, and airy to improve photosynthetic ability, nutrient concentration, development of shoots and buds, advantage in flowering and fruiting, anti-storm, and reduction of pests (Tran, 1999). Regular light pruning is essential for good yield. Pruning of old branches will promote new growth, resulting in more flowering and fruiting (Abu Baker Siddiqui, 2001). Unwanted branches should be pruned to provide definite shape and to promote growth of the trunk and crown of the tree. Three to four branches 60-75 cm from ground opposite to each other are allowed to form the proper frame of the tree. Further, crowded and crisscross branches are removed to facilitate better growth. Non-fruiting, unproductive branches inside the canopy in growing and mature trees should also be pruned. Dried, diseased and scissors-shaped branches should also be periodically removed. Light pruning after harvesting has been found congenial for better growth, fruiting and yield. While harvesting the fruit the

panicle are plucked along with 8-10 cm of twig to promote new flush and better bearing for the succeeding year (Singh and Babita, 2001).

Heavy pruning is to be avoided, except in the case of too much vegetative growth, when heavy shoot pruning is recommended. Root pruning to a depth of 5 cm is also helpful for floral initiation (Xuming, 2001). The young trees are usually topped at a height of 50-60 cm in order to allow 3-4 lateral shoots to develop into the main branches so that the canopy will form a semi-dome shape. The management of young tree aims at promoting tree growth and expanding the tree canopy. Shoot growth of young non-bearing litchi trees is fast and the shoot growth cycle is frequent, 5-6 shoot growths/year. The bearing trees are pruned during autumn and winter. Autumn pruning is done after harvest and before autumn shoot growth to encourage vigorous shoot growth. The trees are pruned to allow good light penetration and good ventilation in the orchard. Winter pruning should be slight and is done before spring shoots or panicle emergence, removing the diseased or pest damaged and weak twigs and thinning out overlapping ones. Bearing trees are managed to acquire a balance between vegetative growth and reproductive growth. After harvesting, two autumn flushes are fostered to form strong fruiting shoots for the coming year (Xuming, 2001).

In brief, the pruning give an efficacy that is not so high as the insecticide on the insect pests. In two systems, pruning give efficacy in Thanhha district higher than that in Chilinh district by hibernant environment for the insect pests in Chilinh district, in litchi orchards and bushy, forest tree that is more abundant than that of Thanhha district, in litchi orchards only.

6.2.5 Removal practice

Besides application of the insecticides and the pruning, the removal method is also considered to be effective tool for managing the insect pests. The removal method can be understood as the application of the local knowledge to capture, trap, and kill the insect pests. The findings showed that the removal method also brought about certain effectiveness in insect pest management (Table 6.12). However this method was applied effectively for two insects only, the litchi stinkbug and the looper. The main reason for

ineffective application for the fruit borer was that the litchi farmers couldn't monitor the larvae of the fruit borer. When hatching, larvae bore immediately inside the fruit. Effectiveness of the removal method was very modest. Average effective rate of the removal method was 5.9% and 5.4% for the litchi stinkbug in Thanhha and Chilinh districts, respectively. Meanwhile this rate was 8.8% and 7.7% for the looper in Thanhha and Chilinh districts, respectively. The difference of the efficacy between the litchi stinkbug and the looper is by the difference in application method. Looper is applied both hand removal and soil trap methods, of which the soil trap is more efficacy than the hand removal. In general, the removal methods for the looper are more efficacious than the method applied for the litchi stinkbug, urine application and capture of the hibernant litchi stinkbugs.

6.2.5.1 Practices for the litchi stinkbug

6.2.5.1.1 Capture by urine application

Human's urine is considered as not only a fertilizable source for the crops, but also for capturing the litchi stinkbug. By accumulating the local knowledge over many ten years, the litchi farmers have known of how to use the urine to capture the litchi stinkbug. First, pure and fresh urine must be ready to use, then a pole that is as long as the tree's height is taken. A head is bound closely with a bundle of rag or rice straw. Dipping the head with a bundle of rag or rice straw into the urine tank, waiting for around 2 minutes to make sure that the bundle is soaked completely. Continuously raising the pole and touching on the litchi stinkbug in anywhere you see. The smell and liquid of the urine impact immediately on the adults and larvae of the litchi stinkbug to make them stop the activities and drop down. Lastly that is the job collecting and killing them.

This is a very efficient practice but this application requires a lot of labor to carry out. So the growers applied this practice at the beginning time of the season (early March) when some adults of the litchi stinkbug start to work again and reproduce from hibernation.

6.2.5.1.2 Capture of the hibernant litchi stinkbugs

By basing on knowledge of where the litchi stinkbugs are hibernating, the litchi farmers can capture and kill the litchi stinkbug separately or in combination with the pruning. Where the litchi stinkbugs like to hibernate are as follows:

- The litchi tree
- The bushy twigs with much sunshine and sheltered from the wind
- The trees with a lot of the fruits, and
- The big trees.
- The trees next to the village
- The trees in surrounding areas of the litchi orchards
- The bushy twigs

Like the capture by urine application, this application also requires a lot of labor to carry out. So the litchi farmers applied this only for small size of the litchi orchard, and during hibernation of the litchi stinkbug (September to February). Besides above applications, some litchi farmers also carry out picking down the hatches of the litchi stinkbug's egg during the adults' reproductive phase. In some cases, when temperature is lower than 10°c, the adults are very difficult to fly. So the adults will be dropped down if the trees are shaken. This is the time they could be captured and killed.

6.2.5.2 Practice for the looper

6.2.5.2.1 Application of the soil trap

By basing on knowledge of the pupation characteristics of the looper in the soil, the litchi farmers made use of this to capture and kill the full larvae of the looper.

When the larvae are in the last instar, they must crawl down and pupate in the soil (Figure 6.2). The litchi farmers turn over the soil around the foot of the litchi trees in a depth of 6 – 10 cm and the width of the same canopy to trap the larvae come to

pupate, after that they put under the harrowed area with a sheet of plastic. The harrowed area induces an attractive environment to lure the larvae. When they crawl down to pupate, the sheet of plastic will prevent them from pupation in layer of deep soil, so they must pupate in the shallow soil layer above the sheet of plastic in a certain time and the litchi farmers would come, capture, and kill them. The looper occurs and damages 4 times a year. The first litter is from March to early May, the remaining litters are from July to November. However the most important litter is the first, from March to early May. This is the litter damaging seriously on young leaves, flower, and young fruit.

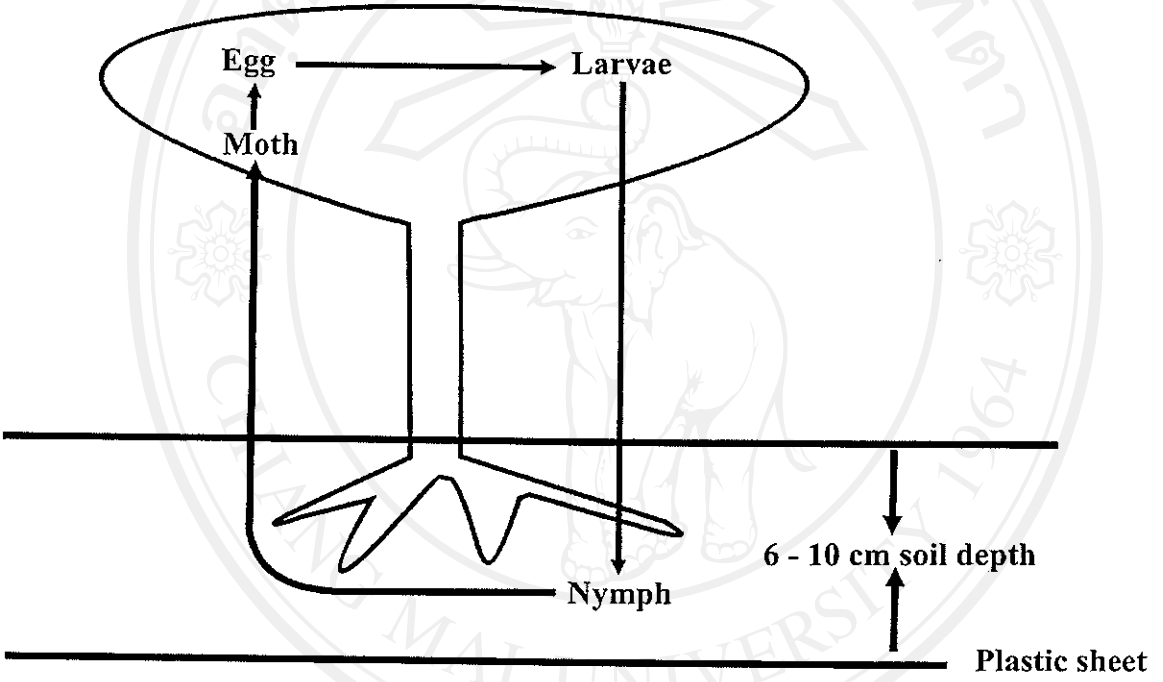

Figure 6.2 Life cycle of the looper and the application technique of soil trap

Besides above application, some litchi farmers also carry out catching and killing or picking down the larvae and hatches of the litchi stinkbug and looper's egg. However this application is very difficult to carry out in a large scale because of the requirement of many labors.