SURVEY OF PEST CONTROL PRACTICES OF CABBAGE FARMERS IN WEST JAVA, INDONESIA

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SUMMARY

Cabbage is one of the most important vegetable crops in Indonesia. Cabbage production improvement in Indonesia is constrained by various factors including crop damage by two main pests: diamondback moth (DBM), *Plutella xylostella,* and cabbage head caterpillar (CHC), *Crocidolomia pavonana*. Attacks by these two pests together can cause complete cabbage yield loss if appropriate control measures are not undertaken, especially during the dry season.

This study updates that of Rauf *et al.* (1993) and was conducted to evaluate current pest control practices implemented by brassica growers in Indonesia to provide the necessary baseline for calculation of the possible role of Bt transgenic brassicas in the future. Work on the technical and environmental feasibility of Bt brassicas will take place under a Programme for Biosafety Systems project from 2005-2008. The main activity of the current study was a survey of pesticide use by cabbage growers in West Java. As supporting information, literatures on resistance of cabbage pests to insecticides, pesticide residues in cabbage, and IPM programmes for cabbage pests were also surveyed and discussed.

The survey of pesticide use by cabbage farmers was conducted in cabbage producing areas in Cianjur/Sukabumi, Bandung, and Garut regencies, West Java during September-October 2004. Two sub-districts in each of the three districts were selected as survey areas and in each sub-district 20 farmers were selected. The respondents were randomly selected among cabbage farmers in study locations. The survey was carried out by one-to-one interviews using a structured questionnaire.

Results of the survey show that, consistent with the general understanding, *P. xylostella* and *C. pavonana* were the most prevalent pest problems faced by respondents and insecticides were intensively used to control the pests (4 to 15 pesticide applications per crop season). Season-long IPM training through farmer field schools (FFS) had been undertaken by 2.5% to 25% of farmers depending on the district. Despite these IPM extension programmes, with c.2,500 vegetable farmers trained in IPM through FFS since 1989, about 90% of respondents still carry out pesticide spraying on a scheduled

basis or on the simple presence of the pests and not on the use of economic threshold levels (ETLs). Most insecticides used by respondents are neurotoxicants which can harm human health and kill beneficial organisms. Very few farmers (only about 5%) used the sprayed microbial insecticide *Bacillus thuringiensis* (*Bt*) or implemented IPM components/ methods in cabbage pest control practices. Pesticide expenses mostly contributed 10%-30% of total cabbage production costs and for more than two-thirds of respondents spending on insecticides alone accounted for 80-100% of the total pesticide costs. Most farmers are aware of negative impacts of pesticides on human health and beneficial organisms but in practice not all farmers followed the rules of safe use and storage of pesticides and in some cases safety precautionary measures were not duly observed.

Available literature in Indonesia indicates that *P. xylostella* is capable of developing resistance to some insecticides, including *Bt* LC_{50}s of deltamethrin and profenofos to *P. xylostella* larvae from Lembang (West Java) were reported to increase 16.9- and 2570-fold, respectively, in 2001 compared with that in 1988, while LC_{50}s of the Bt formulation Dipel WP in 1991, 1995 and 2001 were 1.6, 13.0 and 30.2 times higher than that in 1983. Despite intensive insecticide application against cabbage head caterpillar *C. pavonana*, published reports on resistance of this pest to insecticides are not available. Data on pesticide residues in cabbage are still very scarce. There is no routine government monitoring of residues, even for the c$US12 mill of cabbage exported annually. One study in Bogor (West Java) found that residues of the tested pesticides on cabbage were still below their maximum residue limits.

The population of DBM in some major cabbage growing areas can be adequately curbed by its larval-pupal parasitoid *Diadegama semiclausum* Hellen (Hymenoptera: Ichneumonidae) when insecticides are not used intensively. In areas where CHC is also prevalent, farmers normally rely heavily on synthetic insecticides to control the pest because there are no effective biological control or other non-chemical measures readily available against CHC. Intensive use of insecticides against CHC will badly interfere with the activity of *D. semiclausum* which in turn may cause the collapse of cabbage IPM at farmer level.

In the authors' opinion, given the relatively poor uptake of knowledge-intensive IPM programmes and increasing problems with conventional insecticide resistance, effective

Bt cabbages could play a very useful role in suppressing DBM and perhaps reducing the impact of CHC. The human health, residue and cost savings could be considerable. However, the efficacy of Bt transgenic plants against CHC needs be established. Given the propensity of DBM to develop resistance to insecticides, including to sprayed Bt formulations, in order to maximize the chances of sustainability of such an approach it would be important to ensure that more than one previously un-used and non-cross resisting toxins were used i.e. a stacked gene approach.

I. THE IMPORTANCE OF BRASSICAS IN INDONESIA

In term of planted area, brassica vegetable crops altogether (cabbage, chinese cabbage, etc.) represent the second most important vegetable commodities in Indonesia after chili (Figure 1 and Appendix 2). Cabbage and chinese cabbage land areas were fairly stable from year to year in the last four years (2000-2003) with average cropped areas of about 62.7 and 45.4 thousand hectares annually (the same land is generally cropped more than once per year). In term of average production, cabbage ranked first among the major vegetable crops in Indonesia (Figure 2 and Appendix 2) with an average annual production of about 1.28 million tons.

Cabbage is commonly grown in the highlands of a number of provinces in Indonesia but its cultivation could also be found in some lowland areas due to the availability of cabbage varieties which are adapted to lowland conditions such as KK-Cross, Summer Autumn and Green Coronet (Permadi 1993). West Java has the largest cabbage areas with average cultivated areas of about 19,255 ha per year in the last four year, followed by Central Java (12,854 ha), North Sumatra (9,628 ha) and East Java (9,131 ha). Cabbage is also commonly grown to a smaller extent (about 1,300 – 3,300 ha) in South Celebes, Bengkulu, West Sumatra and Bali (Appendix 3).

Despite extensive cabbage cultivation in Indonesia, nearly all cabbage seed supplies were imported from other countries including Japan, The Netherlands, and Denmark. Import of cabbage seeds was estimated as not less than 6,000 kg of seeds worth of about one billion rupiah annually (Permadi 1993). Attempts to develop high quality cabbage seeds locally have not been successful.

Cabbage produce can be marketed easily in fresh or processed forms because cabbage constitutes an important element of daily dishes of Indonesian people. It is not uncommon to find cabbage being served raw along with a variety of other leafy vegetables in Sundanese restaurants (the Sundanese are an ethnic group native to West Java). Thus, cabbage produce supplied to these restaurants should be free of pesticide residues. Cabbage is also an essential element of a kind of vegetable dish ("gado-gado" or "pecel"/Indonesia style "salad") comprising of a variety of steamed vegetables mixed with peanut-based paste. Marketed preserved vegetable products that contain cabbage include "sauerkraut", "kimchi" ("asinan": salted vegetables), and coleslaw.

Table 1 Exports and imports of three major vegetable crops (thousand tonnes) for Indonesia, 1998-2003*

Commodity	Activity	1998	1999	2000	2001	2002	2003
Cabbage	Export	31.14	40.03	39.82	48.29	49.42	42.69
	Import	0.21	0.57	0.52	0.70	0.45	0.55
	Balance	30.93	39.46	39.30	47.59	48.97	42.14
Shallot	Export	176.31	8.60	6.75	5.99	6.79	5.40
	Import	43.01	35.78	56.71	47.95	32.93	42.01
	Balance	133.30	(37.18)	(49.96)	(41.96)	(26.14)	(36.61)
Onion	Export	0.0	0.28	0.16	2.47	3.28	1.03
	Import	140.53	178.79	174.70	206.93	228.70	222.68
	Balance	(140.53)	(178.51)	(174.54)	(204.46)	(225.42)	(221.65)

* Source: Ministry of Agriculture of Indonesia. Export and import of horticultural products in post-crisis period. http://database.deptan.go.id. Accessed on December 6, 2004.

Table 2 Table 1 Value of exports and imports of three major vegetable crops (USD millions) in Indonesia, 1998-2003*

Commodity	Activity	1998	1999	2000	2001	2002	2003
Cabbage	Export	4.45	6.09	5.51	6.87	9.76	11.40
	Import	0.23	0.99	0.45	0.47	0.33	0.53
	Balance	4.22	5.10	5.06	6.40	9.43	10.87
Shallot	Export	0.05	2.77	1.84	1.67	2.19	2.42
	Import	11.49	9.07	12.91	12.48	9.07	12.37
	Balance	(11.44)	(6.30)	(11.07)	(10.81)	(6.88)	(9.95)
Onion	Export	0.00	0.2	0.05	0.52	1.3	0.38
	Import	47.01	41.44	44.12	52.09	53.26	50.12
	Balance	(47.01)	(41.42)	(44.07)	(51.57)	(51.96)	(49.74)

* Source: Ministry of Agriculture of Indonesia. Export and import of horticultural products in post-crisis period. http://database.deptan.go.id. Accessed on December 6, 2004.

In the last six year period following the monetary and economic crisis (1998-2003), cabbage has been one of the most export vegetable commodities from Indonesia. Exports of cabbage from Indonesia in 1999-2003 increased significantly compared with 1998, while international trade of shallot and onion suffered large deficits (Table 1). In term of foreign earnings, surpluses in cabbage exports increased steadily from 4.22 million UD$ in 1998 to 10.87 million US dollars in 2002,while deficits in international trade of shallot and onion amounted to 6.3-11.44 million UD$ and 41.42-51.96 million of US dollars, respectively over the period (Table 2).

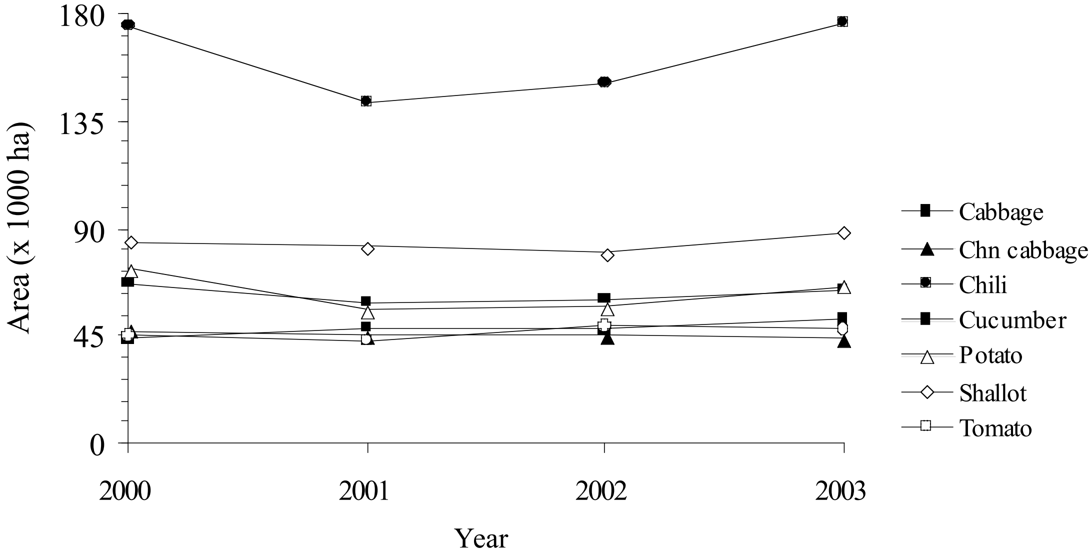

Figure 1 Trends in cultivated areas of major vegetable crops in Indonesia in 2000-2003 Extracted from Agricultural Statistics Database: Vegetable Area and Production Data. Ministry of Agriculture. http://database.deptan.go.id/bdspweb/f4-free-frame.asp. Accessed on December 6, 2004

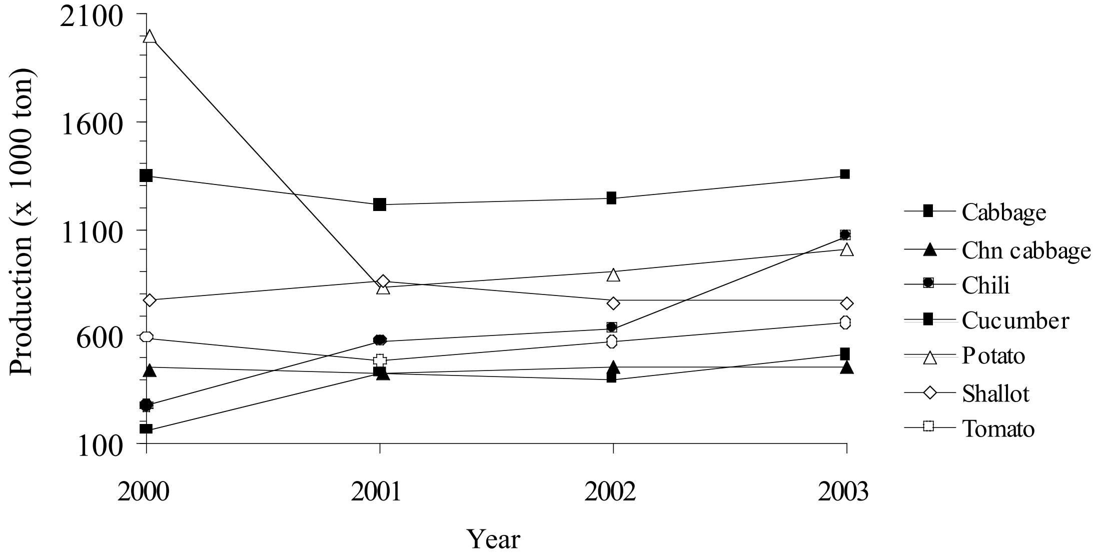

Figure 2 Trends in production of major vegetable crops in Indonesia in 2000-2003
Source: Agricultural Statistics Database: Vegetable Area and Production Data. Ministry of Agriculture. http://database.deptan.go.id/bdspweb/f4-free-frame.asp. Accessed on December 6, 2004.

II. SURVEY OF PEST CONTROL PRACTICES AND THEIR IMPACTS

METHODOLOGY

The survey of pesticide use by cabbage farmers was conducted in the cabbage producing areas in Cianjur/Sukabumi, Bandung, and Garut regencies, West Java from October 1 to 10, 2004. Several districts in three regencies were selected as survey areas. The distribution of respondents by district is shown in Table 3. The respondents were randomly selected among cabbage farmers in three regencies. The survey was carried out by one-to-one interviews using the structured questionnaires attached in Appendix 1. In each sub-district 20 farmers were selected as respondents.

Table 3 Distribution of respondents of cabbage survey in three districts of West Java

District	Sub-district	Number of respondents
Garut	Bayongbong	20
	Cisurupan/Cikajang	20
Bandung	Lembang	20
	Pangalengan	20
Cianjur/Sukabumi	Pasirdatar	20
	Cipanas	20
Total		**120**

RESULTS

Characteristics of Respondents

There was relatively large variation in the age of farmers. In the locations of the survey, most farmers were middle aged (31-50 years) - 52.5%, 60.0% and 62.5% for Cianjur/Sukabumi, Bandung and Garut, respectively. However there were many younger generation cabbage farmers (20-30 years old) especially the Cianjur/ Sukabumi regency. It seems that the agriculture sector is still quite attractive to the younger generation in those areas. No farmer was less than 20 years old (Table 4). However, the percentage of respondents older than 60 years of age was 10.0%, 17.5% and 17.5% in Cianjur/Sukabumi, Bandung and Garut, respectively. This may indicate that the agriculture sector, especially vegetable cultivation, is still being pursued in the traditional way, with the older farmer generations being replaced by younger generations brought up on the farm.

More than 50% of the farmers in the three regencies had only attended the elementary school and there were a few farmers who had never attended formal education (Table 4). Some farmers had higher levels of educational background, even up to university level. Given the low education level of farmer respondents, it seems that the farmers relied only mainly on their own experiences in cabbage cultivation and sometimes they were reluctant to accept new technology.

The experience of respondents in cabbage cultivation varied from less than 5 years to more than 10 years (Table 4). In Cianjur/Sukabumi, Bandung and Garut, the more experienced farmers (more than 10 years) accounted for 50%, 65% and 40% of respondents. These groups of farmers may have chosen vegetable cultivation as their lifelong means of livelihood. Succession of cabbage growing in Garut was more obvious than that in Cianjur/Sukabumi and Bandung as evident by the higher percentage of respondents with experience of less than 5 years in Garut (35%) than in the latter two locations (Table 4).

Farmer respondents generally owned only small cabbage farms. Most farmers managed cabbage farms with area of 0.1-0.5 ha (40%-50%) and some owned less than 0.1 ha piece of cabbage land (Table 5). Nevertheless, there were a few farmers (about 5%) that managed cabbage farms with area of more than 1.5 ha. Owing to the limited agricultural land managed by farmers, land utilization was generally very intensive. Farmers commonly planted another crop before the existing crop was completely harvested.

Table 4 Socio-demographic profile of cabbage farmers interviewed in West Java, 2004

Profile	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Age class (years)			
Less than 20	0	0	0
20-30	22.5	10.0	12.5
31-40	32.5	27.5	15.0
41-50	20.0	32.5	47.5
51-60	15.0	12.5	7.5
More than 60	10.0	17.5	17.5
Level of education			
None	17.5	10.0	7.5
Elementary school	55.0	67.5	70.0
Junior high school	10.0	5.0	7.5
Senior high school	15.0	15.0	10.0
University	2.5	2.5	5.0
Experience in cabbage cultivation (years)			
Less than 5	22.5	7.5	35.0
5-10	27.5	27.5	25.0
More than 10	50.0	65.0	40.0

Table 5 Distribution of size of cabbage farms owned by farmer respondents

Cabbage land area (ha)	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Less than 0.1	25.0	10.0	20.0
$0.1 \leq x < 0.5$	42.5	50.0	52.5
$0.5 \leq x < 1.0$	7.5	20.0	12.5
$1.0 \leq x < 1.5$	20.0	15.0	12.5
$1.5 \leq x < 2.0$	2.5	2.5	2.5
More than 2.0	2.5	2.5	0

Pests and Diseases

When farmer respondents were asked about the degree of pest and disease infestations on cabbage, most of them (> 60%) mentioned that the diamondback moth *Plutella xylostella*, cabbage head cluster caterpillar *Crocidolomia pavonana* (syn. *C. binotalis*), and clubroot disease (*Plasmodiophora brassicae*) frequently cause serious damage (Table 6). Simultaneous infestation by these pests and disease could cause complete yield loss of cabbage. *P. xylostella* and *C. pavonana* constitute two main problems that hamper cabbage production in all survey locations, even during rainy season. Moderate infestation levels were generally reported for cabbage center grub *Hellula undalis* and black cutworm *Agrotis ipsilon*. Severe infestation of *H. undalis* was generally limited to lowland and midland areas during dry season under hot and dry conditions. Severe attacks by cutworm *A. ipsilon* were limited to seedling stage. Infestations by leaf flea beetle *Phyllotreta vittata* and bacterial rot (*Erwinia carotovora*) were generally considered mild, but moderate to severe infestations by *P. vittata* could occur in lower areas during the dry season when the weather was very hot and dry. The presence of *H. undalis* and *P. vittata* in all survey locations suggests that the population of these two pests should be regularly monitored since excessive insecticide applications against the main pests *P. xylostella* and *C. pavonana* may cause outbreaks of those two secondary pests, especially during the dry season.

Table 6 Degree of pest and disease infestation as reported by cabbage farmers

Pests and diseases	**Percentage of respondents**		
	Cianjur/Sukabumi	**Bandung**	**Garut**
Plutella xylostella			
Severe	75.0	65.0	72.5
Moderate	12.5	27.5	25.0
Mild	5.0	7.5	2.5
Not sure	7.5	0	0
Crocidolomia pavonana			
Severe	77.5	62.5	72.5
Moderate	10.0	30.0	12.5
Mild	5.0	2.5	15.0
Not sure	7.5	5.0	0
Hellula undalis			
Severe	45.0	25.0	20.0
Moderate	17.5	32.5	5.0
Mild	5.0	5.0	52.5
Not sure	32.5	37.5	22.5
Phyllotreta vittata			
Severe	15.0	2.5	0
Moderate	22.5	37.5	22.5
Mild	32.5	42.5	45.0
Not sure	30.0	17.5	32.5
Agrotis ipsilon			
Severe	35.0	32.5	22.5
Moderate	32.5	42.5	42.5
Mild	22.5	25.0	32.5
Not sure	10.0	0	2.5
Clubroot			
Severe	65.0	97.5	62.5
Moderate	17.5	0	27.5
Mild	7.5	0	7.5
Not sure	10.0	2.5	5.0
Bacterial rot			
Severe	17.5	32.5	17.5
Moderate	45.0	32.5	25.0
Mild	25.0	32.5	52.0
Not sure	12.5	2.5	5.0

Pesticide Applications

Some 35 insecticide products were reported by respondents to be used for controlling cabbage pests especially *P. xylostella* and *C. pavonana*, and eight fungicide products were used for disease control (Table 7). Active ingredients that make up those insecticide products consist, 6 kinds of organophosphates (7 products), 6 kinds of pyrethroids (8 products), 5 kinds of carbamates (5 products), 3 kinds of chemicals of microbial origin (5 products), and four other kinds of synthetic insecticides (4 products). The 6 *Bt* sprayable products contain two varieties, i.e. *Bt* var. *kurstaki* (4 products) and *Bt* var. *aizawai* (2 products).

In Cianjur/Sukabumi, insecticide products commonly used farmers were Proclaim 5 SG (57.5%), Curacron 500 EC (55%), and Dursban 20 EC (30%); in Bandung Proclaim 5 SG (75.0%), Agrimec 18 EC (37.5%), and Curacron 500 EC (35%); in Garut Proclaim 5 SG (62.5%), Decis 2.5 EC (50%), Success 25 SC (37.5%), and Curacron 500 EC (32.5%) (Table 7). Proclaim 5 SG is a newer, more IPM compatable product containing emamectin benzoate which chemically belongs to the same group as abamectin (a natural insecticide of microbial origin). This insecticide has high activity against a variety of insect pests. Unlike abamectin which was originally developed in the U.S.A., emamectin benzoate marketed in Indonesia is imported from China so that the latter chemical is cheaper than the original abamectin and cabbage farmers can more readily afford to buy Proclaim 5 SG.

There were very few farmers who used Bt. The proportion of farmers in the survey sample using *Bt* products in Cianjur/Sukabumi, Bandung and Garut were only 2.5%, 5% and 2.5%, respectively (Table 7). Four products contain *Bt* var. *kurstaki*, i.e. Agrisal WP, Bactospeine WP, Dipel WP and Thuricide HP, and two products contain *Bt* var. *aizawai*, i.e. Florbac FC and Turex WP. See appendix 5 for a list of Bt products registered in Indonesia. Farmers generally prefer fast-acting insecticides to slow-acting insecticides. It is not easy to convince farmers that *Bt* is equally as effective as most synthetic insecticides in term of crop damage that could be prevented. Farmers consider that any larvae still present on crop could still do the damage although *Bt*-intoxicated larvae cease feeding long before death. Thus, an innovative extension approach is needed if the use of sprayed *Bt* in cabbage pest control is to be increased.

Table 7 Pesticides used by farmers to control cabbage pests and diseases

Trade name	Common name	Percentage of respondents		
		Cianjur/ Sukabumi	Bandung	Garut
Insecticides				
Agrimec 18 EC	Abamectin	12.5	37.5	22.5
Agrisal	Bt	5.0	2.5	0
Ambush 2 EC	Permethrin	0	2.5	5.0
Bactospeine WP	Bt	0	2.5	0
Basudin 60 EC	Diazinon	0	0	2.5
Buldok 25 EC	Beta-cyfluthrin	0	5.0	0
Callicron 500 EC	Profenofos	2.5	2.5	7.5
Chix 25 EC	Beta-cypermethrin	0	5.0	0
Confidor 200 SL	Imidacloprid	0	2.5	2.5
Curacron 500 EC	Profenofos	55.0	35.0	32.5
Cymbush 50 EC	Cypermethrin	0	15.0	0
Decis 2,5 EC	Deltamethrin	15.0	22.5	50.0
Dipel WP	Bt	10.0	2.5	2.5
Dursban 20 EC	Chlorpyrifos	30.0	15.0	0
Elsan 60 EC	Fenthoate	0	0	2.5
Florbac FC	Bt	0	10.0	12.5
Furadan 3 G	Carbofuran	5.0	0	0
Hopcin 50 EC	BPMC	0	2.5	0
Lannate 25 WP	Methomyl	0	0	5.0
Marshall 200 EC	Carbosulfan	0	0	2.5
Matador 1 WP	Lambda-cyhalotrin	15.0	10.0	2.5
Mipcin 50 WP	MIPC	0	0	2.5
Orthene 75 SP	Acephate	10.0	2.5	2.5
Pegasus 500 SC	Diafenthiuron	0	0	2.5
Pounce 20 EC	Permethrin	0	0	7.5
Proclaim 5 SG	Emamectin benzoate	57.5	75.0	62.5
Prothol 10 EC	Emamectin benzoate	0	5.0	0
Regent 50 SC	Fipronil	5.0	0	0
Sherpa 50 EC	Cypermethrin	20.0	0	0

Table 7 *Continued*

Trade name	Common name	Percentage of respondents		
		Cianjur/ Sukabumi	Bandung	Garut
Insecticides				
Success 25 SC	Spinosad	2.5	0	37.5
Tamaron 200 LC	Methamidophos	0	0	5.0
Thiodan 20 WP	Endosulfan	0	2.5	0
Thuricide HP	Bt	0	5.0	0
Turex WP	Bt	0	7.5	0
Tracer 120 SC	Spinosad	0	15.0	15.0
Fungicides				
Antracol 70 WP	Propineb	47.5	57.5	67.5
Curzate 8/64 WP	Cymoxanyl + mancozeb	2.5	7.5	0
Daconil 75 WP	Chlorothalonyl	0	7.5	22.5
Dithane M-45 80 WP	Mancozeb	6.0	0	12.5
Pilaram 80 WP	Maneb	2.5	5.0	0
Score 250 EC	Difenoconazole	2.5	2.5	0
Vondozeb 80 WP	Mancozeb	0	5.0	0
Victory 80 WP	Mancozeb	5.0	0	0

There are, of course, advantages in that *Bt* causes minimal disruption to natural enemies in the system compared to conventional insecticides and has considerable human health benefits.

In addition to insecticides, farmer respondents also used fungicides to control cabbage diseases. The most commonly used fungicide product was Antracol 70 WP (Table 7). Unlike shallot and tomato growers who often apply different insecticides in mixtures, cabbage growers seldom do so. Cabbage growers, however, sometimes mix pesticides whose targets belong to different groups of organisms, e.g. a certain insecticide is mixed with a fungicide or a pesticide sticker. Some farmers even used fungicides not for controlling a particular cabbage disease, but as insecticide stickers.

Farmers chose insecticides based on insecticide efficacy, price and speed of killing action. Most farmers (≥ 95%) chose a certain insecticide because of its effectiveness

(Table 8). Proven effectiveness of a given insecticide will encourage a farmer to continually use that insecticide. A farmer will usually switch to a different insecticide when a the previously used insecticide shows signs of decreasing efficacy against target pests or when a pesticide sale agent launches a penetrating promotion program and offers an insecticide which is as effective as, and cheaper than, the commonly-used insecticide. Another important consideration in choosing an insecticide is its price. 30%-47.5% of respondents preferred relatively cheaper insecticides to the more expensive ones. Only a few farmers (2.5%-7.5%) chose an insecticide based on its fast killing-action property although this property has arguably been taken into account in the "effective" response. The farmer's term "effective" generally includes fast killing-action property.

Table 8 Factors that farmers consider in choosing pesticides

Property	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Effective	97.5	95.0	100.0
Cheap	40.0	47.5	30.0
Fast action	2.5	2.5	7.5

Most respondents (75%-80%) received information about pesticides from pesticide kiosk owners (Table 9). Other sources of information about pesticides were pesticide sales agents (reported by 50% of respondents in Canjur/Sukabumi and 47.5% in Bandung) and fellow farmers (reported by 40%-45% of respondents in Bandung and Garut). Less than 20% of respondents relied on information from agricultural extension agents and respondents that learned about pesticides by reading product labels were even fewer (< 7.5%). It is interesting to note that although a pesticide sale agent may supply exhaustive information about a new product, the farmers usually did not switch to the promoted pesticide right away, instead they will wait to find out the efficacy of that pesticide in the field.

Table 9 Source of information on pesticides

Sources of information	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Extension agents	12.5	17.5	7.5
Pesticide salesmen	50.0	47.5	22.5
Kiosks	75.0	80.0	75.0
Fellow farmers	20.0	45.0	40.0
Pesticide labels	7.5	2.5	5.0

Most cabbage farmers (80%-82.5%) mentioned that they sprayed insecticides on cabbage from less than one week after planting and thereafter the spraying was repeated regularly at a certain time interval. The frequency of insecticide application on cabbage varied from less than four times to more than 15 times per crop. In Cianjur/Sukabumi and Bandung, 42.5% and 55% of respondents, respectively, applied pesticides on cabbage 10-15 times per crop (Table 10). In each of the three survey locations, some farmers (17.5%) applied pesticides more than 15 times per season.

When respondent farmers were asked about the results of their above-mentioned pesticide applications, 82.5%-95% of them expressed their satisfaction because pest infestation and crop damage could be suppressed (Table 10). A few farmers (5%-15%), however, said that pesticide applications did not have any effect at all on pest infestation. One respondent in Bandung even stated that pesticide application could bring about increased pest populations and infestations. This group of respondents might have chosen sub-optimal insecticides because some insecticides reported in Table 7, notably permethrin and deltamethrin, are actually no longer effective against cabbage pests in some major cabbage growing areas in West Java (*see* discussion on insecticide resistance in the previous chapter). Other probable explanations are that those farmers may not have applied pesticides at the proper time and with the correct techniques of pesticide application. As usual with hand-application equipment some pests on underside the leaves will have escaped the pesticide because of poor coverage on the surfaces of the leaves.

Table 10 Pesticide applications on cabbage

Pesticide application	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
First application (WAP)*			
1	82.5	82.5	80.0
2	15.0	15.0	5.0
3	2.5	0	10.0
4	0	0	5.0
Depending on damage level	0	2.5	0
Frequency per crop season			
< 4 x	5.0	0	2.5
4-6 x	17.5	10.0	37.5
7-9 x	17.5	17.5	15.0
10-15 x	42.5	55.0	27.5
> 15 x	17.5	17.5	17.5
Effect			
Decreasing pest (larvae) infestation and crop damage	95.0	82.5	92.5
No effect	5.0	15.0	7.5
Increasing pest (larvae) infestation and crop damage	0	2.5	0

* WAP means week after planting

Scheduled insecticide spraying was practiced by about half of respondent farmers (57% in Cianjur/Sukabumi, 45% in Bandung and 50% in Garut) (Table 11). Some farmers (35%-47%) would do spraying whenever pests in any number were found on their crops, and only a few respondents (5%-7.5%) carried out spraying based on pest infestation level. This may suggest that IPM extension has not penetrated the pest control attitudes and practices of most cabbage growers contacted in this study.

Table 11 Criteria of timing of insecticide applications as reported by cabbage farmers

Criteria for timing	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Scheduled	57.5	45.0	50.0
Presence of pests	35.0	47.5	45.0
Degree of pest infestation	7.5	7.5	5.0

In spraying, most respondents (67%-85%) used pesticides in mixtures (Table 12). The mixtures usually comprised pesticides which were targeted against different groups of pest organisms such as a mixture of an insecticide and a fungicide. More than 60% of respondents stated that the main reason for using pesticide mixtures was that pesticide mixtures could control various pests and diseases simultaneously. Another reason was that applying pesticides in mixtures could save time and labour. This, of course, has human health and resistance implications.

Table 12 Reasons for using pesticide mixture as reported by cabbage farmers

Farmer practice	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Pesticide cocktails			
Yes	85.0	75.0	67.5
No	15.0	25.0	32.5
Reason for using pesticide mixtures			
Efficient in time	20.0	25.0	22.5
Less labour	15.0	12.5	12.5
Control all pests and diseases	65.0	62.5	65.0

Pesticide Safety and Storage Practices

Most cabbage growers interviewed (65.0%-77.5%) stored pesticides around the house (Table 13). Farmers had no place of choice in storing pesticides except around the house because they did not have any suitable, secure place in the farm to store pesticides. Farmers stored pesticides for stocks (pesticides were generally purchased together with other production inputs such as fertilizers to save transportation cost), or the remaining pesticides from previous application (farmers generally had a small cabbage farm so that the pesticide stock could not be used up in one application).

When asked about the place where pesticides were stored, most respondents in Cianjur/Sukabumi (63.3%) and Bandung (46%) answered that they stored pesticides in a cupboard in the house, while 61.3% of respondents in Garut stored pesticides in a cupboard outside the house (Table 13). Some farmers in Bandung (34.6%) and Cianjur/Sukabumi (20%) stored pesticides under wooden benches, and a few farmers (6.5%-13.3%) in the three survey locations stored pesticides on the house floor. These data indicate that farmer knowledge about safety of pesticide storage was very limited. Farmer knowledge about pesticide safety was probably limited to the hazard related to acute pesticide toxicity during application. Pesticide storage around the house can pose health hazards to farmers and their families due to inhalation of pesticide vapour or contamination of food and drinks. Pesticides stored on house floor are dangerous to children who often carry out activities on the floor.

Table 13 Practices in storing pesticides as reported by cabbage growers

Place of storage	**Percentage of respondents**		
	Cianjur/Sukabumi	**Bandung**	**Garut**
Storing pesticides in the house			
Yes	75.0	65.0	77.5
No	25.0	35.0	22.5
Places for storing pesticides			
In cupboard inside house	63.3	46.0	25.8
In cupboard outside house	3.3	7.7	61.3
Under wooden bench	20.0	34.6	6.5
On floor	13.3	11.5	6.5

During pesticide spraying, most respondent farmers (70%-77.5%) walked downwind, a few farmers walked against the wind (5%-7.5%) or perpendicular to the wind (≤ 5%), and the rest of respondents (15%-22.5%) answered “do not know” (Table 17).

Most respondents (>90%) wore some kind of protective clothing during pesticide spraying such as long-sleeved shirts, long pants, boots and hat (Table14). The use of masks and gloves was more limited. This may increase the probability of pesticide poisoning through inhalation and skin contact. It seems that hot and humid weather in the tropics make farmers uncomfortable wearing complete protective clothing, especially mouth and nose masks.

Table 14 Pesticide spraying practices and protective clothing used by cabbage farmers

Spraying particulars	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Direction of spraying			
Downwind	77.5	70.0	75.0
Against the wind	7.5	5.0	5.0
Perpendicular to the wind	0	2.5	5.0
Do not know	15.0	22.5	15.0
Protective clothing used			
Mask	37.5	7.5	25.0
Long pants	97.5	100.0	97.5
Long sleeves	92.5	92.5	95.0
Boots	82.5	97.5	92.5
Gloves	45.0	20.0	15.0
Hat	82.5	72.5	82.5

Poisoning may occur when farmers re-enter cabbage fields that were previously sprayed with pesticides. Most respondents (87.5%-97.5%) mentioned that they re-entered the field in less than 48 hours after spraying (Table 15). This may pose health hazards to farmers since the safe re-entry period for most pesticides is at least 72 hours after spraying. Seemingly most farmersdid not know the safe minimum time intervals for reentering the field after spraying or chose to ignore them. Survey respondents did not post ‘danger’ signs in newly sprayed fields.

Table 15 Re-entry period after pesticide spraying reported by cabbage growers

Reentry period	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Less than 48 hours	87.5	97.5	90.0
From 48 to 72 hours	7.5	2.5	5.0
More than 72 hours	2.5	0	2.5
Uncertain	2.5	0	2.5

Safe disposal of used pesticide containers generally was not practiced by respondent farmers. About half of respondents (40%-52.5%) disposed of used pesticide containers in the fields and some (52.5% of respondents in Cianjur/Sukabumi, 27.5% in Bandung and 25% in Garut) buried used containers in the soil (Table 16). Some other respondents disposed of used containers in the river or burned them. A few respondents (2.5%-7.5%) even sold used pesticide containers to buyers of used bottles and cans.

After pesticide spraying, farmers usually wash their sprayers right away. Sprayer washing was commonly done in the fields (40%-62.5%) or at the river (20%-42.5%) (Table 16). However, a few farmers (2.5%-12.5%) washed their sprayers at the edge of house wells. The rest (10%) did not wash their sprayers.

Table 16 Disposal of used pesticide containers and place for washing pesticide sprayers

Variables	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Disposal of used pesticide containers			
Disposed in field	40.0	40.0	52.5
Piled	2.5	12.5	2.5
Buried	52.5	27.5	25.0
Disposed into river	12.5	10.0	17.5
Sold (cans, bottles)	5.0	2.5	7.5
Burned	5.0	32.5	5.0
Place for washing pesticide sprayers			
At river	37.5	20.0	42.5
At the edge of well	12.5	10.0	2.5
In farm/field	40.0	62.5	47.5
No washing	10.0	12.5	10.0

Knowledge on Impact of Pesticides

Respondent farmers generally knew that pesticide use can cause negative impacts on human health. Most farmers (70%-92.5%) answered 'yes' when asked whether pesticides could cause health hazard (Table 17). Most respondents have also been aware of negative impacts of pesticide use on non-target organisms. More than half of respondents (55%-75%) mentioned that pesticide use could badly affect beneficial insects, fishes, birds, chickens, cats, dogs, and goats, but some respondents (15%-37.5%) stated otherwise, and the rest (5-15%) answered 'do not know'. Farmers' knowledge and awareness about pesticide hazards can at least render farmers more careful and likely to adopt necessary safety measures in applying pesticides so that negative impacts of pesticide use on non-target organisms can be minimized. Appropriate extension programs on safe and effective use of pesticides should be designed and implemented so that all farmers are aware of the health and environmental hazards of pesticide use and know that they are expected to observe necessary safety measures in applying pesticides. Government extension agents should be empowered to undertake extension activities on safe and effective use of pesticides and pesticide sale agents should cooperate earnestly in such extension programmes.

Table 17 Awareness of cabbage farmers about negative impacts of pesticides on non-target organisms

Nontargets	**Percentage of respondents**		
	Cianjur/Sukabumi	**Bandung**	**Garut**
Human			
Yes	92.5	82.5	70.0
No	7.5	12.5	15.0
Do not know	0	5.0	15.0
Beneficial insects			
Yes	65.0	65.0	52.5
No	15.0	25.0	35.0
Do not know	20.0	10.0	12.5
Fish			
Yes	72.0	72.5	67.5
No	15.0	20.0	27.5
Do not know	12.5	15.0	5.0
Bird/chicken			
Yes	57.5	55.0	57.5
No	25.0	37.5	37.5
Do not know	17.5	7.5	5.0
Cat, dog, goat			
Yes	62.5	70.0	57.5
No	22.5	22.5	37.5
Do not know	15.0	7.5	5.0

Pesticide Poisoning

In this survey, respondent farmers were asked whether they have ever experienced any pesticide poisoning after applying pesticides. The commonest symptom of pesticide poisoning experienced by respondent farmers was headache, which was reported by 75% of respondents (Table 18). This symptom is consistent with the fact that most insecticides used by farmers (*see* Table 7) are nerve poisons. Other common symptoms were red eyes (reported by 35.7% of respondents in Cianjur/Sukabumi and 32% in Garut). Fewer farmers reported that they have ever experienced pesticide poisoning with the following symptoms: vomiting, stomach pain, fatigue, blurred vision, itchy skin, and difficulty in breathing.

Regarding the first remedial measures undertaken in the case of pesticide poisoning, only a few respondents (8%-20%) said that they visited a medical doctor to treat health problems suffered after pesticide spraying (Table 18), and this action was limited to cases of severe sickness. Farmers generally have not been aware of of the relationship between their sickness and pesticide poisoning. Many farmers considered such sickness a sign of hungry or unhealthy body condition. Most respondents (53.6%-75%) treated any sickness which may have been due to pesticide poisoning by themselves. A significant proportion of respondents (12%-39.2%) did not undertake any specific action to treat such sickness. It is noted that farmers have learned that pesticides can cause chronic health problems in addition to acute poisoning.

In addition to pesticide poisoning suffered by farmers, some respondents (15%-30%) mentioned that they have noticed the death of livestock and poultry, such as goats and chickens, due to pesticide poisoning (Table 19). The death of livestock occurred because grass for livestock feed were taken from fields that were newly sprayed with pesticides, especially insecticides. Again, this indicates that farmer's knowledge on health and ecological hazards of pesticides was still limited and necessary safety measures in pesticide application were not always observed.

Table 18 Symptoms of pesticide poisoning experienced by cabbage growers and action undertaken in the case of poisoning

Poisoning particulars	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Symptoms			
Headache	78.6	88.0	76.0
Vomiting	7.1	4.0	8.0
Unconsciousness	0	0	8.0
Stomach pain	10.7	4.0	16.0
Fatigue	7.1	8.0	16.0
Red eyes	35.7	16.0	32.0
Blurred vision	10.7	0	20.0
Itchy skin	14.3	16.0	24.0
Diarrhea	0	0	0
Difficulty in breathing	0	8.0	12.0
Action undertaken in the case poisoning			
Go to the doctor	10.7	8.0	20.0
Treated by himself	53.6	64.0	75.0
No action	39.3	28.0	12.0

Table 19 Cases of pesticide poisoning of livestock and poultry reported by cabbage growers

Cases of poisoning	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Livestock			
Have seen	15.0	25.0	20.0
Never seen	85.0	75.0	80.0
Poultry			
Have seen	27.5	27.5	30.0
Never seen	72.5	72.5	70.0

Pesticide Expenses

In cabbage cultivation, the cost of the pesticide component generally represented 10 to 30% of the total production cost (Table 20). More than half of chemical control cost was contributed by spending on insecticides, and even more than 65% of respondents in the three survey locations mentioned that the spending on insecticides amounted to 80%-100% of the total pesticide costs. By considering the kinds of insecticides used by farmers (Table 7), it is clear that their largest proportion of spending on insecticides was aimed at controlling two main cabbage pests, i.e. diamondback moth, *P. xylostella* and cabbage head caterpillar, *C. pavonana*.

Table 20 Relative expenses on pesticides reported by cabbage farmers

Pesticide expenses	Percentage of respondents		
	Cianjur/Sukabumi	Bandung	Garut
Pesticide expenses as % of total production cost			
≤ 10	15.0	15.0	25.0
>10-30	55.0	75.0	65.0
>30-50	27.5	7.5	7.5
> 50	2.5	2.5	2.5
Insecticide expenses as % of total pesticide cost			
30-40	5.0	2.5	0
>40-50	7.5	0	0
> 50-60	0	2.5	2.5
>60-70	5.0	5.0	2.5
>70-80	15.0	15.0	25.0
>80-90	25.0	20.0	30.0
>90-100	42.5	55.0	40.0

Implementation of IPM

Only 10% of respondents in Cianjur/Sukabumi, 25% in Bandung, and 2.5% in Garut have participated in Farmer Field School (FFS) training (Table 21). In the FFS, farmers are trained to 'learn-by-doing' using IPM concepts and methods directly in the field. The low participation in FFS is rather surprising since most lead vegetable farmers in West Java are reported to have participated in FFS and 2,500 vegetable farmers nationally have been trained between 1989 and 1998. IPM methods commonly practiced by FFS alumni, especially in Garut and Bandung, are liming of cabbage field to increase soil pH which in turn is expected to control clubroot disease. Weekly monitoring of cabbage field was undertaken by some FFS alumni. Some FFS alumni (30%) in Bandung applied action thresholds for decision making in insecticide application, and used parasitoids to suppress population of *P. xylostella* larvae. Among respondent farmers who have participated in FFS, only 20%-25% of respondents in Cianjur/Sukabumi and Bandung used *Bt*. products, while in Garut none of FFS alumni used *Bt*. Clearly, more efforts have to be made if IPM methods are to be widely disseminated to cabbage farmers.

Table 21 Participation of respondent farmers in Farmer Field School (FFS)

FFS participation	**Percentage of respondents**		
	Cianjur/Sukabumi	**Bandung**	**Garut**
No	90.0	75.0	97.5
Yes	10.0	25.0	2.5

III. INSECTICIDE RESISTANCE AND RESIDUES

Insecticide Resistance

There have been a only a few studies on insecticide resistance in cabbage pests, especially the diamondback moth (DBM) *Plutella xylostella*, in Indonesia. In all the studies reported, no standard reference strain which has pristine susceptibility was included. The studies which were claimed as "resistance tests" were actually comparative susceptibility tests involving populations of DBM collected from different cabbage producing areas. The "relative resistance" was usually determined by comparing the toxicity (LC_{50}) of a given insecticide to a certain field population with that to the most susceptible field population. Thus, the population that was used as "the susceptible strain" was determined after the testing and analysis of toxicity data were completed.

The first case of insecticide resitance in DBM was reported by Ankersmit in 1954 (Ankersmit 1954). In that report, the DBM population in Lembang-Bandung, West Java, was reported having developed resistance to DDT based on the increase in field rate required to give the same level of control as occurred the first time DDT was used. DDT had to be increased to a rate of 40 kg/ha compared with the initial rate of only 1 kg/ha to give the same level of control. Ankersmit's report represents the first report of insecticide resistance in DBM in the world literature.

Other reports on insecticide resistance in DBM in Indonesia did not appear until 30 years later when Adiputra (1984) reported the results of comparative susceptibility of DBM larval populations from cabbage producing regions in West Java and Central Java to several insecticides including the first generation pyrethroid permethrin. The DBM population from Lembang-Bandung was more tolerant to permethrin than that from Pacet-Cianjur (West Java). It seems that DDT resistance in DBM has conferred cross-resistance to permethrin due to the similar mode of action of the two insecticides which interfere with the function of the sodium channel in the nerve axon.

In 1996 Setiawati reported variation in the susceptibility of DBM larval populations from Lembang, Pangalengan and Garut (all in West Java) to *Bacillus thuringiensis* (*Bt*) formulations, but no standard strain with pristine susceptibility was included in the study. The most susceptible DBM population to *Bt* formulations came from Pangalengan or Garut, never from Lembang (Table 22). This is possibly due to the longer history of *Bt* spraying in Lembang than in the other two locations. Susceptibility of DBM to *Bt* var. *kurstaki* varied with the formulation. The DBM population from Lembang was 27 times more tolerant than that from Pangalengan to Dipel WP, one of the oldest *Bt* formulations available in the market.

Variations in susceptibility of DBM larval populations from three study locations to formulations containing *Bt* var. *aizawai* were not as great as those to *Bt* var. *kurstaki* formulations. The most tolerant DBM population to *Bt* var. *aizawai* formulation was only about 2.7 times more tolerant than the most susceptible population. *Bt* var. *aizawai* was marketed about 10 years later than *Bt* var. *kurstaki*. Despite the lack of true standard strain, the above data suggest the probability of resistance development of DBM to *Bt*

Setiawati (1996) also summarized the results of bioassays of *Bt* formulations against DBM larvae conducted at different times. The tolerance of DBM larvae to Dipel WP increased about 9 fold in 1991 and 73 fold in 1994 bioassays, compared with that in the 1987 bioassay. The tolerance to Bactospeine WP increased about 23-fold in 1994 compared with that in 1987. The tolerance of DBM larvae to the newer generation of *Bt* product, Florbac FC also increased about 4.7- and 6.7-fold in 1992 and 1994, respectively, compared with that in 1991 (Table 23). Again the inherent weakness of that report was that no real standard strain was included. The results of bioassays can be affected by various intrinsic and extrinsic factors, including the quality of *Bt* formulations used at different time. If those factors are not standardized, bioassays conducted at different time can give large variation in susceptibility data. Nevertheless, large increases in tolerance of DBM larvae to *Bt* formulations over time may indicate the ability of DBM larvae to develop resistance to *Bt* as has been reported from other countries (Glare & O'Callaghan 2000; Shelton *et al.* 1993a and b; Shelton *et al.* 1993b; Shelton *et al*. 2000; Gomez *et al*. 2000).

Listyaningrum *et al.* (2003) reported that DBM larval populations from Central Java and Yogyakarta were still susceptible to *Bt* and chlorfluazuron, but some populations, especially from Kopeng (Central Java) had developed resistance to deltamethrin. Laboratory selection with deltamethrin for seven generations increased the resistance level of DBM population from Kopeng 51-fold.

Variation in susceptibility to *Bt* of DBM larval populations from four major cabbage growing areas in East Java (Bondowoso, Jember, Probolinggo and Malang) was reported by Suharto *et al.* (2003). The DBM population from Probolinggo was 5.8 and 7.9 times more tolerant to *Bt* var. *aizawai* (Bite WP) and *Bt* var. *kurstaki* (Thuricide HP), respectively, than was Bondowoso population. Using the same standard for comparison, the Jember population was 4.8 and 16.8 times more tolerant to those two *Bt* products, while higher tolerance of Malang population (8.6-fold) compared with Bondowoso population only occurred with *Bt* var. *aizawai* Weekly field application of *Bt* var. *aizawai* CG-91 (Turex WP) on cabbage at Bromo Probolinggo increased the resistance level of DBM larvae 9.1-fold.

Moekasan *et al.* (2004) conducted a further study on suscetibility of DBM larval populations from five major cabbage growing areas in Java and North Sumatra to two *Bt* products, three synthetic insecticides (fipronil, deltamethrin and profenofos), and one natural insecticide of microbial origin (abamectin). Again, no real susceptible strain with precisely known history of insecticide exposure was included in this study. The results suggest that deltamethrin and profenofos are actually no longer effective against DBM since their LC_{50} values far exceeded their respective suggested field rate (2000 ppm of products) (Table 24). The response of DBM larvae varied with insecticide tested, but the most susceptible population to each of the six insecticide products tested never came from Lembang (West Java) nor Batu-Malang (East Java) suggesting heavier insecticide applications in these two areas than were in the other three locations. The DBM population from Kejajar/Dieng (Central Java) was still susceptible to all insecticides tested (deltamethrin was not tested). Some non-governmental organizations actively supervise vegetable farmers in Dieng to implement IPM and this may result in low numbers of insecticide applications which can in turn can prevent the development of insecticide resistance.

As in the previous study (Setiawati 1996), in the study of Moekasanetal (2004) the Lembang DBM larval population was the most tolerant to Dipel WP than were the other four populations, but was still susceptible to the newer *Bt* product Crymax WDG (*Bt* var. *kurstaki* EG 7841) and to the natural insecticide abamectin. The Kejajar/Dieng population was the most susceptible to the two *Bt* products (Dipel WP and Crymax WDG). Lembang DBM population was 305 times more tolerant to Dipel WP than was Kejajar/Dieng population (Table 24).

Table 22 Variation in susceptibility of *P. xylostella* larval populations from West Java to *B. thuringiensis*

Insecticide/population	LC_{50} (ppm of formulation)	Tolerance ratio*
Dipel WP (*B. t.* var *kurstaki*, 16,000 IU/mg)		
Lembang	3194.31	26.8
Pangalengan	119.12	1.0
Garut	1226.16	10.3
Bactospeine WP (*B. t.* var *kurstaki*, 16,000 IU/mg)		
Lembang	1008.88	2.5
Pangalengan	1010.28	2.5
Garut	399.42	1.0
Thuricide HP (*B. t.* var *kurstaki*, 16,000 IU/mg)		
Lembang	3106.30	4.4
Pangalengan	3936.27	5.6
Garut	708.38	1.0
Delfin WG (*B. t.* var *kurstaki*, 53,000 IU/mg)		
Lembang	303.25	4.1
Pangalengan	73.74	1.0
Garut	1072.40	14.5
Turex WP (*B. t.* var *aizawai*, 3.8%)		
Lembang	2713.33	2.7
Pangalengan	1219.74	1.2
Garut	989.86	1.0
Florbac FC (*B. t.* var *aizawai*, 7,500 IU/mg)		
Lembang	813.37	1.2
Pangalengan	653.30	1.0
Garut	1567.00	2.4

* Tolerance ratio of the most susceptible population to each *Bt* formulation is taken as 1. Source: Setiawati (1996).

Table 23 Changes in susceptibility of *P. xylostella* larvae from Lembang-Bandung (West Java) to *Bt* products

Insecticide	**LC_{50} (ppm of products) in year**			
	1987	**1991**	**1992**	**1994**
Dipel WP	44	403	-	3,194.31
Bactospeine WP	43	-	-	1,008.88
Thuricide HP	-	-	-	3,106.30
Delfin WG	-	24	-	303.25
Turex WP	-	-	-	2,713.33
Florbac FC	-	122	577	813.37

Source: Setiawati (1996).

Moekasan *et al.* (2004) also reported changes over time in susceptiblity of the DBM larval population from Lembang to three insecticides. The LC_{50} of deltamethrin and profenofos to DBM larvae increased 16.9- and 2570-fold, respectively, in 2001 compared with that in 1988, while LC_{50}s of Dipel WP in 1991, 1995 and 2001 were 1.6, 13.0 and 30.2 times higher than that in 1983 (Table 25).

Table 24 Susceptibility of *P. xylostella* larval populations from some major cabbage growing regions in Indonesia to several insecticides

Insecticide	Population*	LC_{50} (ppm of products)**	Tolerance ratio***
Fipronil (Regent 50 SC)	Lembang (WJ)	712.3	89.1
	Pangalengan (WJ)	707.9	88.6
	Kejajar/Dieng (CJ)	8.0	1.0
	Batu (EJ)	187.3	23.4
	Brastagi (NS)	1,497.3	187.4
Deltamethrin (Decis 2.5 EC)	Lembang	270,037.2	4.1
	Pangalengan	65,950.3	1.0
	Batu	2,619,394.8	39.7
Profenofos (Curacron 500 EC)	Lembang	1,285,205.4	44.1
	Pangalengan	29,172.4	1.0
	Kejajar/Dieng	143,320.5	4.9
	Batu	305,332.6	10.5
B. thuringiensis HD-7 (Dipel WP)	Lembang	7,393.6	305.3
	Pangalengan	1,700.9	70.2
	Kejajar/Dieng	24.2	1.0
	Batu	38.5	1.6
	Brastagi	1,202.5	49.7
B. thuringiensis EG 7841 (Crymax WDG)	Lembang	312.04	2.9
	Pangalengan	1,223.0	11.4
	Kejajar/Dieng	107.6	1.0
	Batu	326.5	3.0
	Brastagi	711.2	6.6
Abamectin (Agrimec 18 EC)	Lembang	5.1	1.5
	Pangalengan	7.6	2.3
	Kejajar/Dieng	51.1	15.3
	Batu	80.7	24.2
	Brastagi	3.3	1.0

* WJ: West Java, CJ: Central Java, EJ: East Java, NS: North Sumatra.

** Field rates: 1000-2000 ppm of products.

*** TR of the most susceptible population to each insecticide product is taken as 1. Source: Moekasan *et al.* (2004).

Table 25 Changes in susceptibility of *P. xylostella* larvae from Lembang to three insecticide products

Insecticide	LC_{50} (ppm of products) in year					
	1983	1988	1991	1992	1995	2001
Deltamethrin (Decis 2.5 EC)	-	16,000	-	37,670	-	270,037
Profenofos (Curacron 500 EC)	-	500	-	2,460	-	1,285,205
B. thuringiensis HD-7 (Dipel WP)	245	-	103	-	3,194	7,394

Source: Moekasan *et al.* (2004).

Insecticide Residues

Data on insecticide residues on cabbage and other vegetables in Indonesia are very scarce due to limited facilities and fund for undertaking insecticide residue studies. There is no routine government residue testing, even of the export shipments of cabbage.

Due to lack of facilities, equipment, and of researchers working on pesticide residues, not many studies has been done over a long period. Studies in 1988 showed that the residues of decamethrin and permethrin on tomatoes, and profenofos on cabbage in Lembang and Pangalengan (West Java) exceeded the maximum permissible levels (Soeriaatmadja and Sastrosoiswojo 1988).

Harun *et al.* (1996) carried out a study to determine residue levels of three kinds of insecticides and three kinds of fungicides in four kinds of fresh vegetables (cabbage, chinese cabbage, tomato and carrot). Samples were collected from a supermarket and three public markets in Bogor during the rainy and dry seasons. In all cases, no residues were detected in carrot. Pest and disease attacks on this crop are known to be much less severe than on the other three vegetable crops under study. Insecticide residues (cartap, permethrin, endosulfan) on three other vegetables during the dry season were generally higher than those on the rainy season but there was no significant difference in fungicide residues (chlorothalonil, maneb and mancozeb) between seasons. On brassica vegetables, insecticide residues were more common than fungicide residues and the reverse was true on tomato. This is consistent with the fact that insect pests cause more serious problems on cabbage than diseases and the reverse is true for tomato especially in the rainy season (leaf blight can cause complete loss of tomato). Residues of all three insecticides studied could be detected in cabbage sampled both in the dry and rainy seasons (up to 0.0062 ppm). Insecticide residue levels in chinese cabbage were much lower than in cabbage. In all cases, the residue levels were still much below the existing maximum residue limits for the respective pesticides.

Ameriana *et al.* (2000) conducted a survey in 1998 on consumer awareness towards pesticide residue-free vegetables, especially tomato and cabbage, involving 90 housewives in Bandung (West Java). Approximately 60% of respondents knew that pesticide residues might be present in tomato and cabbage, and were aware of the hazard of pesticide residues to human health. For tomato, most respondents could easily distinguish tomato that was heavily treated with pesticides from that which was not, but this was not the case for cabbage. In general, consumers had tried to minimize the existing pesticide residues by washing and cooking. In some fresh cabbage samples, insecticide residue inhibition exceeded the allowable limit. Pesticide residue inhibition tests showed that washing alone could not reduce residue levels below the residue inhibition limit, but washing and cooking the produce could.

IV. DEVELOPMENT AND PROSPECTS FOR IPM FOR CABBAGE

The foundation of IPM in cabbage was laid in the early 1950s when the parasitoid *Diadegma semiclausum* was introduced from New Zealand to control *P. xylostella* (Vos 1953). Later, this parasitoid established in major cabbage growing centers at highland areas in Indonesia with the rate of parasitization ranged from 59% to 82% (Sastrosiswojo & Sastrodihardjo 1986).

Biological control using the parasitoid *D. semiclausum* presently constitutes the backbone of IPM against *P. xylostella* and of cabbage IPM as a whole. This parasitoid can adequately control *P. xylostella* population in highland areas when insecticides are not intensively used. The activity of this parasitoid, however, is often badly interfered with by intensive use of insecticides particularly against *C. pavonana* because up to the present there are no effective biocontrol agents against the latter pest (Sastrosiswojo & Setiawati 1992). The results of the survey of pesticide use by cabbage farmers as described earlier show that cabbage farmers use insecticides intensively to control the two main cabbage pests. Most insecticides used by farmers are neurotoxicants and very few farmers (only about 5%) use *Bt* Moreover, some farmers have not followed the rules of safe and effective use of pesticides so that farmer practices in using insecticides can cause health and ecological damage. Thus, pest control methods that are effective against the two main cabbage pests (*P. xylostella* and *C. pavonana*) but do little harm to human health and the environment need to be developed.

IPM Programmes and Practices

The national IPM program in Indonesia was launched in 1989. In addition to conventional extension approach, the national IPM programme also designed Farmer Field Schools (FFS) as a means of training farmers about IPM concepts and methods through the 'learning-by-doing' approach directly in the farmers' fields. By 1998 c.2,500 vegetable farmers had been trained in IPM for cabbage and potatoes. IPM components and methods that could be implemented to control cabbage pests include the followings (Sastrosiswojo & Setiawati 1993):

(1) Cultural techniques

(a) Mixed-cropping of cabbage with tomato

Tomato leaves produce an odour that can repel *P. xylostella* adults from laying eggs on cabbage. Tomato is usually planted about one month earlier than cabbage. One row of tomato is planted for every two rows of cabbage.

(b) Adjustment of planting time

At Cipanas-Cianjur (West Java), cabbage planted in November to February (the rainy season) will be less attacked by *P. xylostella* and *C. pavonana* than in the other months. In recent years, however, this method is only appropriate for managing *P. xylostella*, because *C. pavonana* infestation during the rainy season is still relatively high (unpublished data).

(c) Trap crops

Rape (*Brassica campestris* var. *oleifera*) and 'sawi jabung' (*Brassica juncea*) can be used as trap crops for *P. xylostella* and *C. pavonana* and can enhance the function of the parasitoid *D. semicalusum* because flowers of those plants provide nectar for the parasitoid adults.

(d)Mechanical control

- Infestation of black cutworm is usually very severe during the dry season (April-May). The soil-dwelling larvae of this pest can be controlled physically/mechanically by collecting larvae that emerge on to the soil surface at night and killing them.
- Control *C. pavonana* can also be effected by collecting egg clusters and larvae and destroying them.

(2) Use of resistant varieties

White cabbage of Rotan F-1 variety and red cabbage of Marner Rocco variety are somewhat tolerant to *P. xylostella* (under greenhouse conditions).

(3) Biological control

The parasitoid *Diadegma semiclausum* is the most important component of the biological control program against *P. xylostella*. As noted earlier, *D. semiclausum* can adequately control *P. xylostella* when broad-spectrum insecticides are not intensively used, especially in upland areas. Thus, the success of the biocontrol program against *P. xylostella* depends on control methods applied against *C.*

pavonana. Farmers tend to use fast-acting neurotoxic insecticides against *C. pavonana* since effective biological control agents against this pest are still lacking.

Other natural enemies which can check the development of *P. xylostella* populations are a larval parasitoid *Apantelles plutellae* Kurdj. and an egg parasitoid *Trichogrammatoidea bactrae*. These parasitoids are more abundant in cabbage growing areas of low to medium altitude than in the highlands.

The larval parasitosids *Sturnia* sp. and *Eriborus argenteopilosus* (Cameron) are the two most commonly-found parasitoids of *C. pavonana,* but the rate of parasitization is relatively low (about 10%-15%) so that the pest can cause extensive damage if other control measures are not undertaken.

(4) Use of insecticides

To preserve the role of natural enemies of cabbage pests, selective insecticides that can be used to control cabbage pests include *Bt*, acylurea insecticides (chitin synthesis inhibitors), and compounds of microbial origins such as abamectin and spinosad. The selectivity of the last two insecticides is more ecological than physiological due to their short persistence but the lack of contact action helps with the preservation of biological control agents.

The results of pesticide survey as described previously show that emamectin benzoate was often used to control cabbage pests, especially *P. xylostella* and *C. pavonana*. This insecticide is similar in structure to abamectin which was also often used. These insecticides are highly effective against insect pests from a number of different orders. The short persistence of these insecticides can reduce contact hazards to natural enemies. The results of the survey also indicate that hard insecticides, such as profenofos (an organophosphate) and deltamethrin (a pyrethroid), are still in common use. These insecticides are toxic to small natural enemies.

In case hard insecticides are needed to give quick control of high infestation of cabbage pests, it is suggested that non-cross resisted insecticides be used in rotation to reduce negative impacts on beneficial organisms and the environment and to slow down the development of resistance. For example, *Bt* can be included as a component of a rotation with other insecticides.

(5) Control decision making based on action thresholds

Sastrosiswojo and his colleagues have suggested action thresholds for *P. xylostella* and *C. pavonana*. In the absence of effective level of natural enemies, appropriate control measures should be undertaken when the population of *P. xylostella* exceeds 5 larvae per 10 cabbage plants and when egg density of *C. pavonana* exceeds 3 clusters per 10 plants. For *P. xylostella*, when the parasitism by *D. semiclausum* is sufficiently high, the action threshold is determined by considering the rate of parasitization as follows:

$Y = (1 - P) \cdot X$

where Y = population of *P. xylostella* larvae that can actually cause damage

P = proportion of *P. xylostella* larvae parasitized by *D. semiclausum* (expressed as proportion between 0 and 1). Larval parasitization is calculated by sampling 10 larvae (third and fourth instars) from 0.2 ha cabbage crops.

X = population of third and fourth instar larvae *P. xylostella* in the field, based on systematic sampling of 10 sample plants per 0.2 ha of crops..

Criteria for insecticide application:

- If $Y \geq 5$ larvae/10 plants, then insecticide application can be undertaken.
- If $Y < 5$ larvae/10 plants, insecticide application is not necessary.

(6) Botanical insecticides

In addition to the above IPM methods, in the last ten years researchers at Bogor Agricultural University have been actively engaged in research on botanical insecticides. In the laboratory, extracts of the following plants have been shown to possess strong insecticidal activity against *C. pavonana* larvae (mortality ≥ 90% in the treatment with organic solvent extracts at concentrations of not more that 0.5% or with aqueous extracts at concentrations of not more than 5%): seeds of *Annona glabra*, *A. montana*, A. *reticulata*, *A. squamosa*, and twigs of *Uvaria grandifolia* (Annonaceae), stem barks of *Calophyllum soulattri* (Clusiaceae), seeds of *Aglaia elliptica*, *A. harmsiana*, *A. odoratissima*, *Azadirachta indica*, *Dysoxylum mollissimum*, *Trichilia trijuga*, twigs of *Aglaia odorata*, *Chisocheton macrophylla*, *Dysoxylum arborescens*, and leaves and twigs of *Dysoxylum acutangulum* (Meliaceae), seeds of *Piper nigrum* and fruits of *Piper retrofractum* (Piperaceae), stem barks of *Nephelium cuspidatum* (Sapindaceae), and roots of *Eurycoma longifolia* (Simaroubaceae) (Appendix 4).

Extracts which are effective against *C. pavonana* larvae are generally also active against *P. xylostella* larvae.

One of the most active botanical materials recently revealed is twig extract of *Dysoxylum acutangulum* (Meliaceae) (Prisona 1998, Prijono *et al. 2001 and* 2004). The LC_{50} of chloroform soluble fraction of this extract against *C. pavonana* larvae was 107.7 ppm (under the same conditions the LC_{50} of a pyrethroid, betacyfluthrin, was 76.9 ppm).

Botanical insecticides are generally safe to natural enemies and the environment as a whole. Some botanical materials could be easily prepared using simple implements available at farmer level (Prijono 2004). Thus, botanical insecticides have a high potential to be incorporated into IPM programmes for cabbage pests. Information on effective botanical insecticides can be disseminated through conventional extension activities by government extension agents or through IPM training in FFS.

Potential for Bt brassicas in the Indonesian IPM system

The potential for use of transgenic Bt cabbage in the Indonesian system was not directly explored with farmers in this study as action, strengths and weaknesses of transgenic insecticidal crops are not well known in the farming community.

The advantages of such an approach in the Indonesian context would be that, if DBM and CHC were controlled without the need for intensive spraying of conventional insecticides, the prospects for a gradual strengthening of biocontrol would be greatly enhanced. Although clearly benefiting for an IPM context, this component requires no more that the planting of appropriate Bt varieties and as such would be relatively easy to extend through the existing seed sale and extension system. A reduction in spraying of the two key pests of only 50% would result in a 5-15% reduction in the total production costs (depending on seed cost and district).

However, any such strategy would need to take account of the following factors. Sprayed Bt use, though limited, appears to have been sufficiently wide-spread for there to be significant development of resistance to some formulations. Given the speed with which DBM develops resistance world-wide, we suggest that genes for at least 2 toxins (which are not common in the current sprayed material and are not-cross resisted) be inserted. Before any serious efforts are made for deployment of such material it is essential that the efficacy of both toxins be tested against CHC as well as DBM to ensure the sustainability of the strategy. To this end, Bogor University, with other partners in India, USA and Australia is commencing studies of this option under funding from the USA's *Programme for Biosafety Systems* from early 2005.

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Appendix 1

Questionnaire: Survey of Pesticide Use by Cabbage Farmers

Regency	:	Interviewer	: ....
District	:	Date of interview	: ....
Village	:	Place of interview	: ....
Village area	:	Time of interview	: ....

Characteristics of Respondent Farmers

1. Name : ....
2. Age : .... years
3. Education, highest level (tick one) : [ ] Never attended formal school
   [ ] Elementary school
   [ ] Junior high school
   [ ] Senior high school
   [ ] University
4. Main occupation : ....
5. Experience in cabbage cultivation : .... years
6. Area of cabbage farm : .... m^2
7. Status of land ownership : [ ] Owner and worker
   [ ] Tenant
   [ ] Worker
   [ ] Others, please state: ....

Pest and Disease Problems

8. Please state the degree of pest and disease infestations on cabbage grown last season:

Major pests and diseases	Degree of infestation			
	Severe	Moderate	Mild	Do not know
Plutella xylostella (diamondback moth)				
Crocidolomia pavonana (cabbage head caterpillar)				
Hellula undalis (cabbage center grub)				
Phyllotreta vittata (cabbage flea beetle)				
Agrotis ipsilon (black cutworm)				
Plasmodiophora brassicae (clubroot)				
Bacterial rot (black rot and soft rot)				

Chemical Control

9. Please state the types of pesticides used, target pests/diseases, rate of use, frequency of pesticide application per season, and the results of that application:

Type of pesticide (trade mark)	Target pests/diseases	Rate of use	Frequency of application per season	Degree of pest/disease control

10. Please state the reasons why you choose the above pesticides:

[ ] Effective
[ ] Cheap

[ ] Fast action
[ ] Others, please state: ....

11. How did you know about the types of pesticides that could be used to control cabbage pests and diseases?

    [ ] From agricultural extension agents
    [ ] From pesticide company sale agents
    [ ] From pesticide kiosks
    [ ] From fellow farmers
    [ ] By reading pesticide labels
    [ ] By trial and error
    [ ] Others, please state ....

12. Please state the basis for decision-making in pesticide spraying:

    [ ] Presence of damage symptom on leaves
    [ ] Increased degree of pest/disease infestation
    [ ] Neighbouring farmers carry out spraying
    [ ] Time to start scheduled spraying

13. During pesticide application, did you mix different pesticides?

    [ ] Yes [ ] No

14. If your answer to question 12 is 'yes', what was your reasons for using pesticides in mixtures?

    [ ] Saving time
    [ ] Saving labour
    [ ] Controlling different pests/diseases simultaneously
    [ ] Other, please state: ....

Safety in Pesticide Use and Storage

15. If your answer to question 12 is 'yes', what was your reasons for using pesticides in mixtures?

	Yes	No
Face mask	[ ]	[ ]
Long pants	[ ]	[ ]
Long-sleeved shirts	[ ]	[ ]
Boots	[ ]	[ ]
Gloves	[ ]	[ ]

Mouth and nose mask	[ ]	[ ]
Hat	[ ]	[ ]
....	[ ]	[ ]

16. When you did spraying, what was the direction of your walk:

[ ] Against the wind
[ ] Downwind
[ ] Perpendicular to the wind
[ ] Do not know

17. After you sprayed your cabbage field with pesticides, when did you usually reenter your newly sprayed field to observe the results of spraying (to see whether insect pests have been dead or not)?

[ ] Right away after pesticide application
[ ] In the afternoon of the same day (< 24 hours after spraying)
[ ] The following day (24 hours)
[ ] Two days later (48 hours)
[ ] Three days later (72 hours)
[ ] > 72 hours
[ ] Uncertain
[ ] No observation

18. When you bought a pesticide, did you use that pesticide directly in the field or store it first?

[ ] Right away (go to question no. 20)
[ ] Store it first
[ ] Use it in part (the remaining portion was stored)

19. If a pesticide was stored first before use, where did store that pesticide?

[ ] In a cupboard outside the house
[ ] Under a cupboard/bench inside the house
[ ] On house floor
[ ] In a cupboard inside the house

20. How did you dispose used pesticide containers (bottles, cans, etc.)?

[ ] Leaving them scattered in the field
[ ] Piling them at a certain place in the field
[ ] Burying them in soil
[ ] Disposing them at river

[ ] Selling used bottles/cans

21. After pesticide spraying, what did you do with your clothes that you used during spraying?
    [ ] Taking off and washing them
    [ ] Taking off them and keeping them unwashed to be worn again later
    [ ] Keep wearing them at home until the time of afternoon bathe
    [ ] Others, please state ....

22. What did you do with your sprayer after you used it for pesticide spraying?
    [ ] Washing it at a nearby river
    [ ] Washing it at the edge of house well
    [ ] Washing it in the field using available stored water
    [ ] Other, please state ....
    [ ] No washing at all

Awareness towards Impacts of Pesticides on Health and Environment

23. In your opinion, do pesticides cause negative impacts on human health and other nontarget organisms?

Negative impacts on	Yes	No	Do not know
Human health			
Beneficial insects (natural enemies, bees, etc.)			
Fishes at river and pond			
Birds visiting the field			
Cats, goats, and dogs entering the field			

24. Did you ever experience the following sicknesses after spraying pesticides? (please tick all appropriate answers)
    [ ] Headache
    [ ] Vomiting
    [ ] Unconsciousness
    [ ] Stomach pain
    [ ] Fatigue
    [ ] Red eyes
    [ ] Blurred vision

[ ] Itchy skin
[ ] Diarrhea
[ ] Difficulty in breathing

25. If you ever experienced any of the above symptoms, what did you do?

[ ] Visiting a medical doctor (physician) or public health center (Puskesmas)
[ ] Treating the sickness by yourself
[ ] No action (self-recovery)
[ ] Others, please state ....

26. Have you ever seen goats/cows/dogs/cats poisoned by pesticides?

[ ] Yes [ ] No

27. Have you ever seen chickens/ducks/birds poisoned by pesticides?

[ ] Yes [ ] No

Control of Cabbage Pest Caterpillars

28. When did you start spraying your cabbage crop to control cabbage pest caterpillars (*P. xylostella* and *C. pavonana*)?

[ ] .... weeks after planting

29. How many times did you spray your cabbage crop to control cabbage pest caterpillars in one growing season (dry season)?

[ ] .... times per season

30. Please list all insecticides that you used to control cabbage pest caterpillars:

[ ] .... [ ] ....
[ ] .... [ ] ....
[ ] .... [ ] ....
[ ] .... [ ] ....

31. Please describe the results of spraying using the above insecticides:

[ ] Most caterpillars died and pest damage decreased
[ ] Most caterpillars remained alive and pest damage did not decreased
[ ] Number of caterpillars increased and pest damage became severer
[ ] Others, please state ....

32. In your opinion, are there any pesticides that are safe to the environment and beneficial organisms?

[ ] Yes, please state ....
[ ] No
[ ] Do not know

Production Cost Analysis

33. Previously (question no. 6), you mentioned that the area of your cabbage farm was ....m^2. Please, give information on the total production cost for running that cabbage farm.

Production input	**Cost (Rp)**
a. Seeds/seedlings	
b. Animal manure	
c. Inorganic fertilizer	
d. Liquid fertilizer	
e. Pesticides	
f. Labour costs	
Soil tillage	
Planting	
Fertilization	
Weeding	
Pesticide spraying	
Harvesting	
g. Land hire	
h.	

34. Out of expenses for pesticides stated at question no. 31e, what was the proportion of spending that was used to control cabbage pest caterpillars?

[ ] .... %

35. What was the yield of cabbage from your cabbage farm mentioned above?
[ ] .... kg

36. What was your gross revenue from selling your cabbage harvest?
[ ] Rp ....

Integrated Pest Management

37. Did you ever participate in Farmer Field School (FFS)?

[ ] Yes [ ] No (interview completed)

38. If yes (for question no. 37), did you apply knowledge and techniques that you received in FFS in your cabbage cultivation practices?

[ ] Yes [ ] No (interview completed)

39. If yes (for question no. 38), what kind of IPM components that you applied in your cabbage cultivation practices?

[ ] Liming
[ ] Weekly pest monitoring
[ ] Use of action threshold
[ ] Use of natural enemies
[ ] Mechanical pest control
[ ] Use of microbial insecticides (*Bt*)
[ ] ....

40. How were the results of implementation of the above IPM components?

[ ] Use of pesticides decreased from .... times to .... times per season.
[ ] Use of pesticides remained the same, i.e. .... times per season.
[ ] Use of pesticides even increased from .... times to .... times per season.
[ ] Do not know
[ ] Others, please state ....

Appendix 2 Planted area (000 ha) and production (000 ton) of seven major vegetable crops in Indonesia, 2000-2002*

Vegetable crops	2000		2001		2002		2003	
	Planted Area	Prod.	Planted Area	Prod.	Planted Area	Prod.	Planted Area	Prod.
Cabbage	66.91	1,336.4	59.21	1,205.40	60.24	1,232.84	64.52	1,348.43
Chinese cabbage	47.26	454.82	45.28	434.04	45.46	461.07	43.70	459.25
Chili	174.72	279.67	142.5 6	580.46	150.60	635.09	176.26	1,066.72
Cucumber	43.76	166.39	48.29	431.92	47.72	406.14	52.12	514.21
Potato	73.07	2,004.18	55.97	831.14	57.33	893.82	65.92	1,009.98
Shallot	84.04	772.89	82.15	861.15	79.87	766.57	88.03	762.79
Tomato	45.22	593.39	43.12	483.99	49.46	573.52	47.88	657.46

* Extracted from Agricultural Statistics Database: Vegetable Area and Production Data. Ministry of Agriculture. http://database.deptan.go.id/ bdspweb/f4-free-frame.asp. Accessed on December 6, 2004.

Appendix 3 Area (ha) and production (ton) of cabbage by province in Indonesia, 2000-2003*

Province	2000		2001		2002		2003	
	Planted Area	Production	Planted Area	Production	Planted Area	Production	Planted Area	Production
Nanggroe Aceh Darussalam	200	2,921	234	3,233	56	802	575	10,840
North Sumatra	11,641	268,896	8,146	198,605	8,699	242,877	10,027	249,716
West Sumatra	1,786	45,978	1,768	66,216	1,836	21,535	1,632	36,063
Riau	0	0	2	7	0	0	0	0
Jambi	517	16,628	555	22,652	1,268	20,528	2,030	39,809
South Sumatra	238	2,325	225	1,553	156	1,483	256	2,702
Bengkulu	2,690	43,005	1,637	28,113	3,258	55,898	1,662	25,078
Lampung	781	9,049	517	7,019	344	5,756	607	9,883
Bangka Belitung	0	0	0	0	0	0	0	0
Jakarta	0	0	0	0	0	0	0	0
West Java	21,101	501,381	19,788	490,449	17,729	431,208	18,403	438,091
Central Java	13,339	207,005	12,181	185,775	11,537	165,888	14,360	240,134
Yogyakarta	26	822	45	1,358	67	2,324	40	1,025
East Java	9,563	131,986	8,616	121,794	9,277	166,551	9,068	157,411
Banten	0	0	1	3	1	1	0	0
Bali	1,376	51,841	1,290	48,611	1,353	50,468	1,282	51,188
West Lesser Sunda Islands	74	1,034	286	3,211	391	2,868	361	3,086
East Lesser Sunda Islands	212	836	165	679	218	1,799	222	1,208
West Kalimantan	5	22	9	44	22	77	179	688
East Kalimantan	5	18	0	0	1	10	0	0

Appendix 3 *Continued*

Province	2000		2001		2002		2003	
	Planted Area	Production	Planted Area	Production	Planted Area	Production	Planted Area	Production
South Kalimantan	5	18	2	7	2	55	0	0
East Kalimantan	70	414	36	298	80	367	46	185
North Celebes	493	3,846	320	5,740	325	2,457	332	6,456
Central Celebes	191	1,042	138	624	221	1,207	158	2,630
South Celebes	2,449	46,310	2,640	15,831	2,639	54,384	2,721	67,970
Southeast Celebes	113	690	141	968	243	1,669	97	501
Gorontalo	0	0	3	11	5	19	3	5
Mollucas	22	60	67	831	18	115	117	483
Papua	17	281	385	1,772	464	2,469	306	2,741
North Mollucas	0	0	0	0	28	84	36	540
National	**66,914**	**1,336,410**	**59,207**	**1,205,404**	**60,235**	**1,232,843**	**64,520**	**1,348,433**

- Source: Agricultural Statistics Database: Vegetable Area and Production Data. Ministry of Agriculture. http://database.deptan.go.id/ bdspweb/f4-free-frame.asp. Accessed on December 6, 2004.

Appendix 4 Selected data on insecticidal activity of plant materials from Indonesia against cabbage head caterpillar *Crocidolomia pavonana* (by leaf feeding method)

Species (part)[a]	Derivative (concentration)	Mortality (%)	References
Anacardiaceae			
Buchanania arborescens	Water-acetone-methanol (18:1:1) extract (5%)[b]	43.3	Syahputra *et al.* (2001)
Annonaceae			
Annona glabra (sd)	Water extract (0.25%)[b]	80.0	Basana & Prijono (1994)
	Water extract (0.4%)[b]	100.0	Prijono (2004)
A. montana (sd)	Water extract (2%)[b]	93.3	Prijono (2004)
A. reticulata (sd)	Water extract (3.5%)[b]	92.5	Basana & Prijono (1994)
A. squamosa (sd)	Crude methanol extract (0.05%)	100.0	Prijono *et al.* (2004)
	Water extract (0.4%)[b]	93.3	Prijono (2004)
Uvaria grandifolia (tw)	Chloroform fraction of methanol extract (0.5%)	100.0	Prijono *et al.* (2004)
Clusiaceae			
Calophyllum soulattri (stb)	Crude ethanol extract (0.25%)[b]	100.0	Syahputra *et al.* (2004)
	Water-acetone-methanol (18:1:1) extract (5%)[b]	100.0	Syahputra *et al.* (2001)
Euphorbiaceae			
Croton tiglium (sd)	Water-acetone-methanol (18:1:1) extract (5%)[b]	43.3	Syahputra *et al.* (2001)
Lecythidaceae			
Barringtonia lanceolata (stb)	Water-acetone-methanol (18:1:1) extract (5%)[b]	73.3	Syahputra *et al.* (2001)
Meliaceae			
Aglaia elaeagnoidea (lf)	Crude methanol extract (0.5%)	51.1	Prijono *et al.* (2004)
A. elliptica (sd)	Crude acetone extract (0.25%)	73.1	Prijono (1998)
	Ethyl acetate fraction of methanol extract (0.25%)	98.3	Lina & Prijono (1999)
A. harmsiana (sd)	Crude acetone extract (0.25%)	100.0	Prijono (1998)
A. odorata (lf)	Crude methanol extract (0.5%)	69.5	Prijono *et al.* (2004)
A. odorata (tw)	Crude ethanol extract (0.5%)	98.7	Prijono *et al.* (2001)
A. odoratissima (sd)	Crude acetone extract (0.25%)	78.1	Prijono (1998)
	Ethyl acetate fraction of methanol extract (0.25%)	100.0	Lina & Prijono (1999)
Aphanamixis grandifolia (sd)	Crude acetone extract (0.25%)	54.1	Prijono (1998)
Azadirachta indica (sd)	Crude acetone extract (0.25%)	100.0	Prijono (1998)

Appendix 4 *Continued*

Species (part)[a]	**Derivative (concentration)**	**Mortality (%)**	**References**
Meliaceae			
Chisocheton macrophylla (tw)	Crude methanol extract (0.5%)	41.7	Prijono *et al.* (2004)
	Chloroform fraction (0.5%)	100.0	Prijono *et al.* (2004)
Dysoxylum acutangulum (lf)	Crude methanol (0.5%)	70.8	Prijono *et al.* (2004)
	Chloroform fraction (0.5%)	100.0	Prijono *et al.* (2004)
Dysoxylum acutangulum (tw)	Crude methanol extract (0.5%)	100.0	Prijono *et al.* (2004)
	Water extract (2.5%)	96.7	Prijono (2004)
D. arborescens (tw)	Crude methanol (0.5%)	93.2	Prijono *et al.* (2004)
D. mollissimum (sd)	Crude methanol extract (0.5%)	100.0	Prijono *et al.* (2004)
Swietenia macrophylla (sd)	Crude acetone extract (0.25%)	43.9	Prijono (1998)
S. mahagoni (sd)	Crude acetone extract (0.25%)	43.7	Prijono (1998)
Trichilia trijuga (sd)	Crude acetone extract (0.25%)	86.6	Prijono (1998)
	Ethyl acetate fraction of methanol extract (0.25%)	91.5	Lina & Prijono (1999)
	Water extract (2%)	60.0	Prijono (2004)
Piperaceae			
Piper nigrum (sd)	Crude methanol extract (0.5%)	100.0	Prijono *et al.* (2004)
P. retrofractum (fr)	Crude methanol extract (0.5%)	100.0	Prijono *et al.* (2004)
Sapindaceae			
Nephelium cuspidatum (stb)	Water-acetone-methanol (18:1:1) extract (5%)[b]	100.0	Syahputra *et al.* (2001)
Simaroubaceae			
Eurycoma longifolia (rt)	Water-acetone-methanol (18:1:1) extract (5%)[b]	100.0	Syahputra *et al.* (2001)

[a] fr: fruit, lf: leaf, rt: root, stb: stem bark, sd: seed, tw: twig
[b] Plus emulsifier or detergent at 0.025% or 0.1%.

Appendix 5 List of Bt insecticides registered for *Plutella xylostella* in Indonesia (Source: Department of Agriculture. 2002. Pesticides for Agriculture and Forestry).

Trade Name	a.i.
Krist WP	Bacillus thuringiensis var. kurstaki strain 8010: 0,95%
Bacillin WP	Bacillus thuringiensis var. aizawai: 16.000 IU/mg
Bactospeine WP	Bacillus thuringiensis var. kurstaki serotype 3A/3B H.14: 16.000 IU/mg
Baculat WP	Bacillus thuringiensis: 24.000 IU/mg
Bite WP	Bacillus thuringiensis var. aizawai serotipe H-7: 86 x 10^9 spora/gram
Bite FC	Bacillus thuringiensis var. aizawai serotype H-7: 200 g/l
Condor F	Delta endotoksin of Bacillus thuringiensis var. kurstaki strain EG-2348: 71g/l
Costar OF	Bacillus thuringiensis var. kurstaki serotype 3a, 3b, strain SA 12: 36.000 IU/mg
Cutlass WP	Delta endotoksin of Bacillus thuringiensis var. kurstaki strain EG 2371: 10%
Delfin WDG	Bacillus thuringiensis var. kurstaki serotype 3a, 3b strain SA-11: 6,4%
Dipel WP	Bacillus thuringiensis var. kurstaki strain HD-7: 16.000 IU/mg
Florbac FC	Bacillus thuringiensis var. aizawai serotype 7: 7500 IU/mg
Restack WP	Bacillus thuringiensis var. kurstaki serotype HD-1: 16.000 IU/mg (25%)
Thuricide HP	Bacillus thuringiensis var. kurstaki serotype 3a, 3b strain HD-1: 16.000 IU/mg : 3,2%
Turex WP	Delta endotoksin of Bacillus thuringiensis var. aizawai strain GC-91: 3,8%
Xentari WDG	Bacillus thuringiensis var. aizawai: 10,30%