

Sugar Cane Pests' Outbreak in Chonburi Province, Thailand: Impacts and Control

Siriporn Sangsak* and Sumalee Thepsuwan

Faculty of Environment and Resource Studies, Mahidol University, Nakhon Pathom 73170, Thailand

Abstract

The objectives of this research were 1) to examine the history and impacts of sugarcane pest outbreaks in Bor Thong District, Chonburi Province, from 1997 to 2007, 2) to study causes of the outbreaks, 3) to investigate pest control methods sugarcane farmers used and factors influencing the selection of the methods, and 4) to propose suitable alternatives for controlling sugarcane pests in the future. The study focused on three kinds of pests: sugarcane borers, stem boring grubs and sugarcane aphids. This qualitative and quantitative investigation used both primary data from field study and secondary data from relevant printed and online documents. The sample group was randomly selected from 25% of the entire population of the district, yielding 243 samples. Questionnaires and in-depth interviews were utilized to collect the data. The triangulation method was employed to verify the data from 20 key informants and relevant documents. Both statistics and descriptive statistics were used to analyze the data.

The study findings reveal that, during the period of the outbreaks, the most prevalent pest was sugarcane borers (46%), followed by stem boring grubs (32%) and sugarcane aphids (22%) respectively. When a comparison on the correlation between cane production and commercial cane sugar (CCS) resulting from damage caused by sugarcane borers, stem boring grubs and sugarcane aphids is made, it is found that the outbreaks did not have much impact on cane production. However, the outbreaks of stem boring grubs had strongest impact on CCS. Severe outbreaks occurred between 1999 and 2003. A major cause of the outbreaks was local climate change, notably drought. Farmers used different control methods to deal with the three pests. *Trichogramma confusum* and *Proreus simulans* were released into affected plantations to control sugarcane borers, whereas tillage was used to control stem boring grubs. To control sugarcane aphids, more pest-resistant sugarcane breeds were used for cultivation. The factors influencing the selection of pest control methods included health safety, efficiency of pest control and low cost. Suitable pest control methods required by farmers should be easy to put into practice, safe to health and friendly to the environment, low cost, support-oriented from concerned state agencies, and preventive of the recurrence of sugarcane pest outbreaks.

Key Words: Bor Thong/ Sugarcane Pest/ Sugarcane Borers/ Stem Boring Grubs/ Sugarcane Aphids

1. Introduction

Sugarcane is an important economic crop of Thailand and an essential raw material of sugar production industry for export. Although the country is a major

sugarcane and sugar producer and exporter in the world, production per rai is relatively low compared with other countries. Causes of such low production include weather conditions, particularly drought, cultivation methods and

* Corresponding author.

E-mail address: ice_702@hotmail.com

outbreaks of pests, especially sugarcane borers and stem boring grubs, reducing production and its commercial cane sugar levels.

In the eastern region, sugarcane is most cultivated in Chonburi Province, ranked no. 14 of the country list. The crop is grown in every district except Bang Lamung and Satahip. In terms of cultivation area, Bor Thong District has the most. In 2007, it covered 66,171 rai or 33.8% of the cultivation area in the province. Besides outbreaks of sugarcane borers and stem boring grubs in the district like other provinces in the country, there have been outbreaks of sugarcane aphids in the region (Wiwat et al, 1983). Causes of the outbreaks of the three kinds of pests in the district and the entire province have not clearly been identified. As a common practice, when an outbreak occurs, farmers and concerned state agencies use pesticides or chemicals to get rid of pests. However, there are better pest control methods that are safe for farmers and consumers as well as friendly to the environment, such as mechanical control, biological control, cultural control, and integrated insect & pest control. It is therefore interesting to investigate what pest control methods sugarcane farmers used in the past, reasons for using them as well as advantages and disadvantages of those methods. The findings would provide better pest control alternatives for farmers when there is an outbreak in the future.

2. Objectives of the research

1. To examine the history and impacts of sugarcane pest outbreaks in Bor Thong District, Chonburi Province, from 1997 to 2007.
2. To study causes of the outbreaks.
3. To investigate pest control methods farmers used and factors influencing the selection of those methods.

4. To propose suitable and better pest control alternatives to farmers for future use.

3. Methodology

This qualitative and quantitative research used both field data and data from relevant printed and online documents. The sample group consisted of 243 farmers randomly selected from 25% of the entire population in the district. The field data were collected from the questionnaire and in-depth interviews. The triangulation method was used to verify the data from 20 key informants and related documents. The data were analyzed and presented descriptively and statistically.

4. The research findings

1. History of sugarcane pest outbreaks from 1997 to 2007. It is found from the study findings that the sample group was in the age range of 30 to 62 years and 44.8% was in the age range of 41-50 years. There were 83.5% males and 16.5% females. Their educational background was from primary school to graduate school (master's degree). Their sugarcane cultivation experience was from ten to forty years. The cultivation area was from 50 to 800 rai and 93% took the activity as their major career. The production cost was 5,000-8,000 baht per rai. It is further found that 34.6% were members of Eastern Farmer's Association and 31.7% were members of Chonburi Agricultural Career Group Association. As shown in Table 1, there was an outbreak of *Chilo infuscatellus* (Snellen), *Scirpophaga excerptalis* (Walker), *Sesamia inferens* (Walker), *Chilo tumidicostalis* (Hampson) and *Dorysthenes (Lophosternus) bugueti* (Guerin) in 1997 with an outbreak of *Aulacaspie tegalensis* (Zehntner), *Saccharicoccus sacchari* (Cockerell),

Trionymus sacchari (Cockerell), *Dactylpius sacchari* (Cockerell), *Pseudococcus sacchari* (Cockerell) in the following year. Outbreaks of the three kinds of pests took place continuously from 1999 to 2007. In terms of complete damage from the outbreaks, 46% was from sugarcane borers, 32% from stem boring grubs and 22% from sugarcane aphids respectively.

2. Impacts from the outbreaks of sugarcane pests in the district

2.1 Number of affected farmers.

When a sugarcane pest outbreak covers 5% of the whole area of cultivation, it is regarded that there is damage from the

outbreak. Of the 243 samples, it is found that some farmers were affected by the damage caused by only one kind of pest, whereas others were affected by two or three kinds. Nevertheless, 76.6% were caused by only one kind, with 38.3% by sugarcane borers, 23.1% by stem boring grubs, and 15.2% by sugarcane aphids. About 15.2% were damaged by two kinds of pests, notably by stem boring grubs and sugarcane borers, and 8.2% were by all three kinds. When the kinds of pests were considered, it is found that the most prevalent was sugarcane borers, followed by stem boring grubs and sugarcane aphids, as shown in Table 1.

Table 1: Types of sugarcane pest outbreaks in Bor Thong District, Chonburi Province, during 1997-2007 and number of farmers affected by the outbreaks of each pest

Sugarcane pest outbreaks	Cases	Percentage
Sugarcane borers	93	38.3
Stem boring grubs	56	23.1
Sugarcane aphids	37	15.2
Sugarcane borers and stem boring grubs	25	10.3
Sugarcane borers and sugarcane aphids	12	4.9
Stem boring grubs and sugarcane aphids	0	0
All three kinds	20	8.2
Total	243	100.0

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

When the years of the outbreaks were considered, it is found that 2002 was most devastating, with 51 cases or 21% of the whole samples. This is followed by 1999 with 35 cases or 14.4% and 2001 with 34 cases or 14%. The outbreak

caused the least damage in 2007 with only 13 cases or 5.3%. It is noticeable that farmers suffered from the outbreaks more than one year. This means that the outbreaks were recurrent, as shown in Table 2.

Table 2: Number of farmers affected by sugarcane pest outbreaks in Bor Thong District, Chonburi Province, from 1997 to 2007

Year	Sugarcane borers	Stem boring grubs	Sugarcane aphids	Sugarcane pests	
	Cases(N=243)	Cases(N=243)	Cases(N=243)	Cases(N=243)	Percentage
1997	8	19	0	27	11.1
1998	8	14	6	28	11.5
1999 2	20	9	6	35	14.4
2000	15	5	6	26	10.7
2001 3	22	6	6	34	14.0
2002 1	25	16	10	51	21.0
2003	7	10	10	27	11.1
2004	12	7	11	30	12.3
2005	9	5	6	20	8.2
2006	18	5	6	29	11.9
2007	6	5	2	13	5.3
Average	14	9	7		

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

2.2 Area size of the damage.

When a pest outbreak occurs, concerned agencies will evaluate the damage done. During the outbreaks of the study period in the district, it is found that the area affected by sugarcane borers was between 127 and 700 rai, averaging 328.8 rai a year. The area affected by stem boring grubs was between 46 and 506 rai, averaging 182 rai a year, and by sugarcane aphids 30 to 165 rai, averaging 102.6 rai a year.

By year, it is revealed that the most damage caused by sugarcane borers was in 2001 with 700 rai, followed by 2002 with 560 rai. The most damage caused by stem boring grubs was in 1997 with 506 rai, followed by 2002 with 340 rai. The most damage caused by sugarcane aphids was in 2004 with 165 rai, followed by 2002 with 142 rai. Overall, the outbreaks were severe from 1999 to 2003 with sugarcane borers as the most prevalent, as shown in Table 3.

Table 3: Number of farmers and plantation areas affected by sugarcane pest outbreaks in Bor Thong District, Chonburi Province, from 1997 to 2007

Year	Sugarcane borers		Stem boring grubs		Sugarcane aphids	
	Cases (N=243)	Area of the damage (rai)	Cases (N=243)	Area of the damage (rai)	Cases (N=243)	Area of the damage (rai)
1997	8	223	19	506	0	0
1998	8	141	14	298	6	96
1999	20	473	9	154	6	120
2000	15	344	5	46	6	120
2001	22	700	6	68	6	120
2002	25	560	16	340	10	142
2003	7	175	10	225	10	150
2004	12	229	7	160	11	165
2005	9	236	5	64	6	90
2006	18	409	5	69	6	96
2007	6	127	5	72	2	30
Average	14	328.82	9	182	7	102.64

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

2.3 Impacts on sugarcane production and commercial cane sugar (CCS) From the reports of Ocha et al. (1981) and Adisak et al. (2007), it is revealed that, when an outbreak occurs, sugarcane production and CCS are also decreased. For the area of investigation from 1997 to 2007, production was from 7.40 to 8.50 tons/rai, averaging 7.73 tons/rai. From 2005 to 2007, production was higher than 8 tons/rai. Commercial cane sugar (CCS) was from 10.09 to 10.54, averaging 10.20 as shown in Table 4. CCS was below average during 1997-1999, 2001-2002, and 2005, while the rest was higher than average. In 2002, CCS was the lowest, at 10.09. When production during the study period was calculated for correlation with CCS, the correlation was 0.77398, indicating that production and CCS were correlated at a medium level. When production was calculated for correlation with the area of destruction from the outbreaks of sugarcane borers, stem boring grubs and sugarcane aphids, the correlation was -0.42610, -0.43558, and -0.41353 respectively, indicating low or no correlation. When t-test was applied to each pair, it is found that it is significantly different for every pair, as shown in

Table 5. This means that the outbreaks caused little damage to the production. In other words, the outbreaks were not severe enough to have strong impacts on sugarcane production in the district. It is further observed that farmers in the district like to burn cane leaves before harvest to facilitate cutting. The practice generally affects production and CCS in addition to canes being dirty (Office of Cane and Sugar Board, 2010). Consequently, the figures indicating sugarcane production and CCS in this study include those incorporated results of burning. When a comparison on the correlation between cane production and CCS resulting from damage caused by sugarcane borers, stem boring grubs and sugarcane aphids is made, it is found that the outbreaks did not have much impact on cane production. However, the outbreaks of stem boring grubs had strongest impact on CCS. In general, it can be concluded that the outbreaks did not have clear impacts on sugarcane production and CCS in the district. Nevertheless, when the outbreaks of the three kinds of pests are compared, it is found that an outbreak of stem boring grubs tends to have more impact on CCS than that of sugarcane borers and aphids.

In the future, if farmers are able to control the outbreaks at the present level, there will be no threat to their production. If an outbreak is beyond the current extent,

what should be eliminated first is stem boring grubs, followed by sugarcane borers.

Table 4: Comparison of sugarcane production, commercial cane sugar and areas of destruction caused by the three kinds of pests from 1997 to 2007

Year	Sugarcane production (tons/rai)	Commercial cane sugar levels of sugarcane (CCS.)	Areas of destruction caused by the three kinds of pests		
			Sugarcane borers(rai)	Stem boring grubs (rai)	Sugarcane aphids (rai)
1997	7.58	10.10	223	506	0
1998	7.50	10.15	141	298	96
1999	7.52	10.16	473	154	120
2000	7.43	10.20	344	46	120
2001	7.45	10.15	700	68	120
2002	7.40	10.09	560	340	142
2003	7.60	10.30	175	225	150
2004	7.79	10.21	229	160	165
2005	8.10	10.12	236	64	90
2006	8.20	10.50	409	69	96
2007	8.50	10.54	127	72	30
Average	7.73	10.20	328.82	182	102.64

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

Table 5: Correlation between sugarcane production with commercial cane sugar; and correlation between sugarcane production and commercial cane sugar with areas of destruction caused by the three kinds of pests from 1997 to 2007 in Bor Thong District, Chonburi Province.

The correlation between	Correlation coefficient (r)	p- value
Sugarcane production and commercial cane sugar	0.77398	0.00
Sugarcane production and areas destroyed by sugarcane borers	- 0.42610	0.00
Sugarcane production and areas destroyed by stem boring grubs	- 0.43558	0.00
Sugarcane production and areas destroyed by sugarcane aphids	- 0.41353	0.00
Commercial cane sugar and areas destroyed by sugarcane borers	- 0.28731	0.00
Commercial cane sugar and areas destroyed by stem boring grubs	- 0.46526	0.00
Commercial cane sugar and areas destroyed by sugarcane aphids	- 0.20239	0.00

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

4.1 Causes of the outbreaks

From investigating causes of the outbreaks, it is found that 57.6% of the farmers believed the outbreaks stemmed from local climate change, particularly drought, 24.7% from susceptible variety, 23.9% from inadequate care, and 2.5% from pesticide-resistant pests respectively. When weather conditions of the province were examined, it is found that rainfall is 1,200-1,400 mm, with the temperature of

23-36 degrees Celsius and relative humidity of 70-80%. It is evident that the difference between rainfall and relative humidity is quite wide, causing the outbreaks of sugarcane borers. Furthermore, sandy loam soil is favorable to the outbreak of stem boring grubs (Nathakit, 2004). Such a climate change also causes pest outbreaks in sugar plantations in Buriram and Nakhon Sawan Provinces, as shown in Table 6.

Table 6: Causes of sugarcane pest outbreaks according to the farmers

Causes of the outbreaks	Cases(N=243)	Percentage
1. Local climate change	140	57.6
1.1 High temperature	46	18.9
1.2 High humidity	31	12.8
1.3 Low rainfall	45	18.5
2. Susceptible variety	60	24.7
3. Pesticide-resistant pests respectively	6	2.5
4. Inadequate care	58	23.9

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

4.2 Control of sugarcane pest outbreaks

4.2.1 Sugarcane borers. It is found that when there was an outbreak of sugarcane borers, 26.9% of the farmers released *Trichogamma confusum* and *Proreus simulans* into affected fields, 22% destroyed the sugarcane and replaced it with a more resistant variety, 20.6% used integrated pest control methods, and 2.2% did nothing besides weeding, as shown in Table 7.

4.2.2 Stem boring grubs. When an outbreak of stem boring grubs occurred, 33.5% of the farmers employed tillage before planting and after harvest, 30.7%

used hands or tools to destroy the pest, 13.9% resorted to crop rotation, e.g., rice, tapioca or pineapple, 12.9% utilized green fungus or *Metarhizium anisoplia*, and 5.4% did nothing nor used pesticides, as shown in Table 8.

4.2.3 Sugarcane aphids. When there was an outbreak of sugarcane aphids, 42.6% of the farmers changed to a more resistant breed, 25.9% burned the cane during harvest, 24.1% peeled off the leaves, and 4.9% did nothing. It is further found that pesticides were not used but chemicals were used for weeding. The detail is shown in Table 9.

Table 7: Sugarcane borers control methods used by the farmers

Sugarcane borers control methods	Cases(N=243)	Percentage
- Did nothing besides weeding	8	2.2
- Used hands or tools to destroy the pest or burning of sugarcanes	44	12.1
- Tillage between sugarcane beds	35	9.6
- Destroyed the sugarcane and replaced it with a more resistant breed	80	22.0
- Soil mulching after harvest	27	7.4
- Resorted to crop rotation, e.g., rice, tapioca or pineapple	21	5.8
- The farmers released <i>Trichogamma confusum</i> and <i>Proreus simulans</i> into affected fields	98	26.9
- Used pesticides	0	0
- Used integrated pest control methods	75	20.6

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

Table 8: Stem boring grubs control methods used by the farmers

Sugarcane borers control methods	Cases(N=243)	Percentage
Did nothing besides weeding	11	5.4
Used hands or tools to destroy the pest	2 62	30.7
The farmers employed tillage before planting and after harvest	1 70	34.7
A dugout trap	5	2.5
The farmers changed to a more resistant breed	0	0
Used <i>Metarhizium anisoplia</i>	26	12.9
Resorted to crop rotation, e.g., rice, tapioca or pineapple	3 28	13.9
Used pesticides	0	0

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

Table 9: Sugarcane aphid control methods used by the farmers

Sugarcane borers control methods	Cases(N=243)	Percentage
Did nothing besides weeding	8	4.9
Used hands or tools to destroy the pest	4	2.5
The farmers changed to a more resistant breed	1 69	42.6
Burned the cane during harvest	2 42	25.9
Peeled off the leaves	3 39	24.1
Used pesticides	0	0

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

4.3 Factors influencing controls of sugarcane pest outbreaks

Selecting particular pest control methods of farmers depends on various reasons, most notable include safety to users and communities (35.9%), damage reduction of pests (34.3%) and cost-effectiveness (23.9%).

Other reasons for not using a particular method include high cost, long duration to become effective, recurrence of pests, no support from concerned local agencies, labor intensiveness, inability to carry out by oneself, and complicated methods of use. The detail is shown in Table 10.

Table 10: Reasons for selecting pest control methods of farmers

Advantages of pest control methods	Cases(N=243)	Percentage
- Low cost	3 58	23.9
- Simple methods of use	54	22.1
- Support from local state agencies on knowledge and finance	12	4.9
-Immediate effects	35	14.4
-Considered effectiveness of pest destruction	2 83	34.3
- No recurrence of pest	14	5.6
- No negative impacts on the plantation and physical as well as environmental conditions	21	8.6
- The farmers consider health safety of users and community as the main reason	1 87	35.9
- Implementation by oneself	50	20.4

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010.

4.4 Advantages and disadvantages of each pest control method

The comparison of advantages and disadvantages of each pest control method can be summarized as follows:

4.4.1 Sugarcane borers

1) The use of natural enemies like *Trichogramma confusum* and *Proreus simulans*. The advantages of the method included health safety to users and communities, specific attack to the pest, low cost as they are available from sugar production plants or the Provincial Pest Management Center or the District Farmers Office, and reduction of damage. The disadvantages included insufficient quantity of the natural enemies, a long duration to become effective, and complicated methods of use.

2) Change of a better pest-resistant breed. The advantages of this method included health safety to users and communities, easy procedures and reduction of damage. The disadvantages included high cost, recurrence of the pest and labor intensiveness.

3) Integrated pest control methods in one cultivation season. The advantages included reduction of damage, health safety and non-recurrence of the pest. The disadvantages were high cost, labor intensiveness and complicated methods of use.

4.4.2 Stem boring grubs

1) Tillage. The method was used most often by the farmers. The advantages included health safety to users and communities, easy procedures and reduction of damage. The disadvantages were high cost of management, labor intensiveness, a long duration to become effective, and recurrence of the pest.

2) Destruction of the pest by hands or tools. The advantages included health safety to users and communities, easy

procedures, and reduction of damage. The disadvantages were high cost and a long duration to become effective.

3) Crop rotation. The advantages of this method were reduction of damage, health safety to users and communities and easy procedures. The disadvantages included high cost, recurrence of the pest and a long duration to become effective.

4.4.3 Sugarcane aphids

1) Change of a more pest-resistant breed. The advantages of this method included health safety to users and communities, reduction of damage and easy procedures. The disadvantages were a long duration to become effective, high cost and recurrence of the pest.

2) Burning of the sugarcane. The advantages of this method included low cost, reduction of damage and easy procedures. The disadvantages were recurrence of the pest, negative impact on the plantation and no support from local state agencies.

3) Peeling off the leaves. The advantages included health safety to users and communities, reduction of damage and easy procedures. The disadvantages were a long duration to become effective, recurrence of the pest and high cost.

4.5 Suitable pest control alternatives for the future

In controlling sugarcane pests in the future, farmers want control methods or principles with the following characteristics: easy procedures (53.9%), low cost (50.6%), no negative environmental impacts (50.6%), support from state agencies (47.3%), regular dissemination of control methods (41.2%), health safety without side effects (40.7%), no recurrence of outbreaks (40.7%), and adaptability to various contexts (35.8%).

Table 11: Characteristics of pest control methods required by farmers in Chonburi Province

Sugarcane pest control methods	Cases(N=243)	Percentage
Easy procedures	131	53.9
Low cost	123	50.6
No negative environmental impacts	123	50.6
Support from state agencies	115	47.3
Regular dissemination of control methods	100	41.2
Health safety without side effects	99	40.7
No recurrence of outbreaks	99	40.7
Adaptability to various contexts	87	35.8

Source: Interviewing sugarcane farmers in Bor Thong District, Chonburi Province, from March 2009 to March 2010

5. Conclusion

The study findings reveal that the kinds of pest outbreaks during the study period were sugarcane borers (46%), stem boring grubs (32%) and sugarcane aphids (22%) respectively. The outbreaks of the three types of pests were most severe from 1999 to 2003. Damage to sugarcane plantations was mostly caused by one kind of pest. However, 76.6% of the damage was caused by only one kind. The area affected by sugarcane borers was 127-700 rai, averaging 328.8 rai per year, 46-506 rai or 182 rai a year on average by stem boring grubs, and 30-165 rai or 102.6 rai per year on average by sugarcane aphids. When a comparison on the correlation between cane production and CCS resulting from damage caused by sugarcane borers, stem boring grubs and sugarcane aphids is made, it is found that the outbreaks did not have much impact on cane production. However, the outbreaks of stem boring grubs had strongest impact on CCS. In general, it can be concluded that the outbreaks did not have clear impacts on sugarcane production and CCS in the district. Nevertheless, when the outbreaks of the three kinds of pests are compared, it is found that an outbreak of stem boring grubs tends to have more impact on CCS than that of sugarcane borers and aphids. A major cause of the outbreaks was local climate change, notably drought. The farmers used different methods to control

each kind of pest. *Trichogramma confusum* and *prorues simulans* were used to control sugarcane borers while tillage was used to control stem boring grubs. As for sugarcane aphids, the farmers changed to a better pest-resistant breed. The factors influencing the use of pest control methods included health safety, reduction of damage and low cost. An ideal pest control method for the future should be easy to use, without negative health and environmental effects, low cost, supported by state agencies, and preventive of pest recurrence.

6. Recommendations from the research

1. There are weaknesses for each control method. If those weaknesses are improved, the method will be effective in the future.
2. Farmers should be provided knowledge about production, care and utilization of pest parasites in order to solve the problem of slow effectiveness of the method.

7. References

- Adisak, K. et al. 2007. **White-top borers and damage from the outbreaks in Muang District, Utaradit Province.** New Agricultural Research and Development News letter. Department of Agriculture.

- Nathakrit, P. 2004. **Sugarcane pests and control methods**. Sugarcane Academic Document. Field Crops Research Institute, Department of Agriculture, Ministry of Agriculture and Cooperatives. Bangkok: Agricultural Cooperatives Club of Thailand.
- Ocha, P. et al. 1981. “**Damage of sugarcane stem 1 from sugarcane borers**”. The 1981 Research Report. Research Projects on Corn and Farm Crop Pests. Division of Entomology and Zoology, Department of Agriculture Academic. Bangkok: The Agricultural Cooperative Federation of Thailand.
- Office of Cane and Sugar Board. 2010. Burn cane and Sugar burning. [Online]. Available : <http://oldweb.ocsb.go.th> [accessed in July 2010]
- Wiwat, S. et al. 1983. **Pest Management Implementation for Sugarcane Pests**. Department of Entomology, Faculty of Agriculture, Kasetsart University. Bangkok: Institute of Research and Development, Kasetsart University.