

RESULTS

To study the growth, development and survivalship of sugarcane stem boring grubs

1. Under laboratory condition

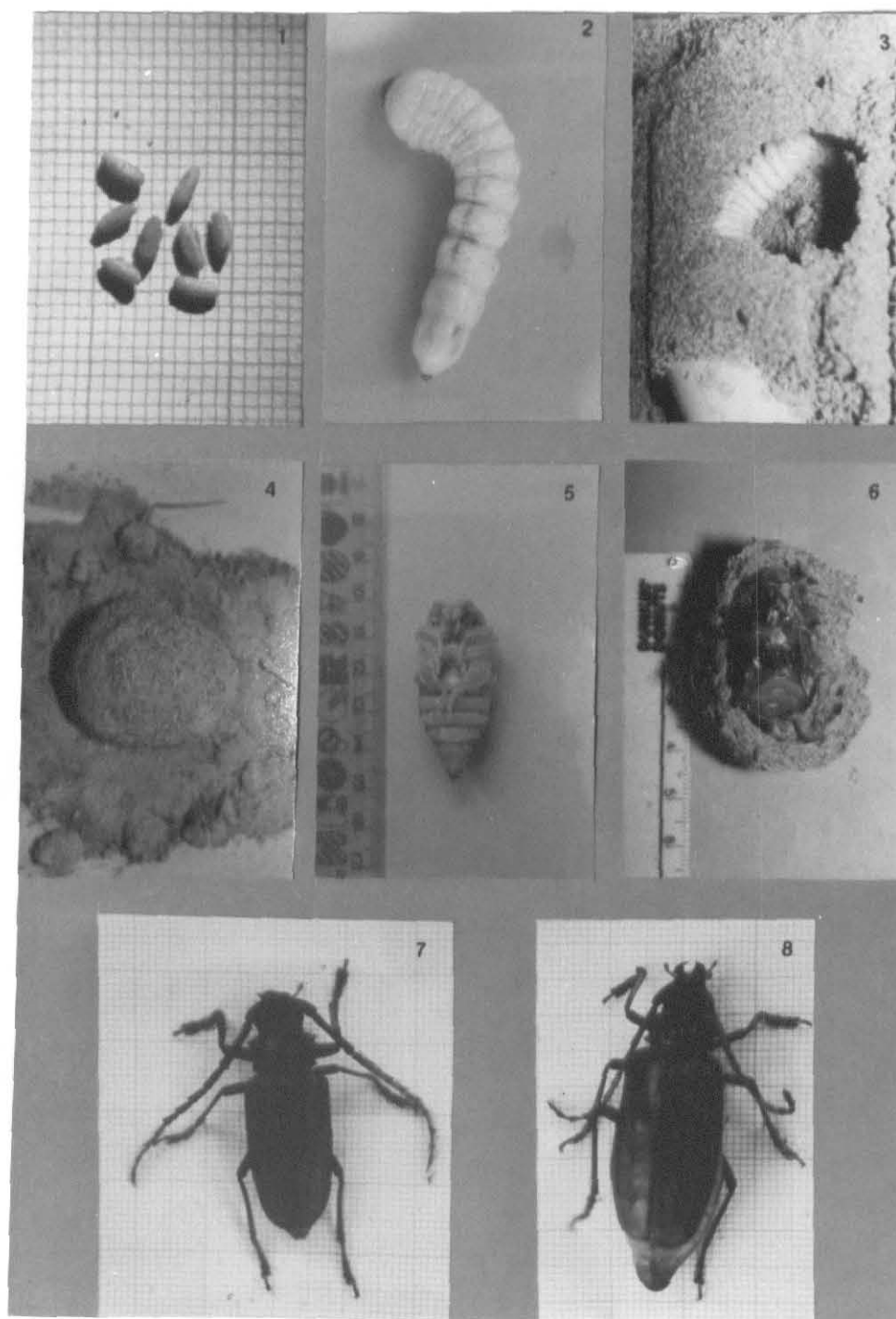
The growth, development and survivalship of sugarcane stem boring grubs were investigated and the results obtained under laboratory condition ($29.9 \pm 0.99^{\circ}\text{C}$ and $78.58 \pm 5.05\%$ RH). The results are presented in the following :-

The egg : The eggs of D. buqueti Guerin are oval, with an average length of 0.32 ± 0.01 mm (range $0.31-0.33$ mm), width of 0.12 ± 0.01 mm (range $0.11-0.13$ mm) (Fig. 1). The newly laid eggs are white and then change to yellow. Finally the eggs turn dark brown before hatching. Under natural conditions the eggs are laid singly by night. A female places her stig into the soil, for oviposition with her body vertical to the surface and an egg is laid every minute. The eggs are laid in $0.6-2.5$ cm (1.5 ± 0.65) of soil dept.

The average number of eggs laid per female is 161.92 ± 116.8 (range 41-441 eggs). The percentage of eggs hatched is 77.97 ± 25.98 per cent (range 25.27-99.29 per cent). The incubation period of eggs is 15.5 ± 3.03 days (range 11-27 days) (Fig. 2).

Figure 1. The life stages of sugarcane stem boring grubs,
Dorysthenes buqueti Guerin.

1	=	Egg stage	5	=	Pupal stage
2	=	Larval stage	6	=	Pre-adult stage
3	=	Pre-pupal stage	7	=	Adult male
4	=	Cocoon	8	=	Adult female



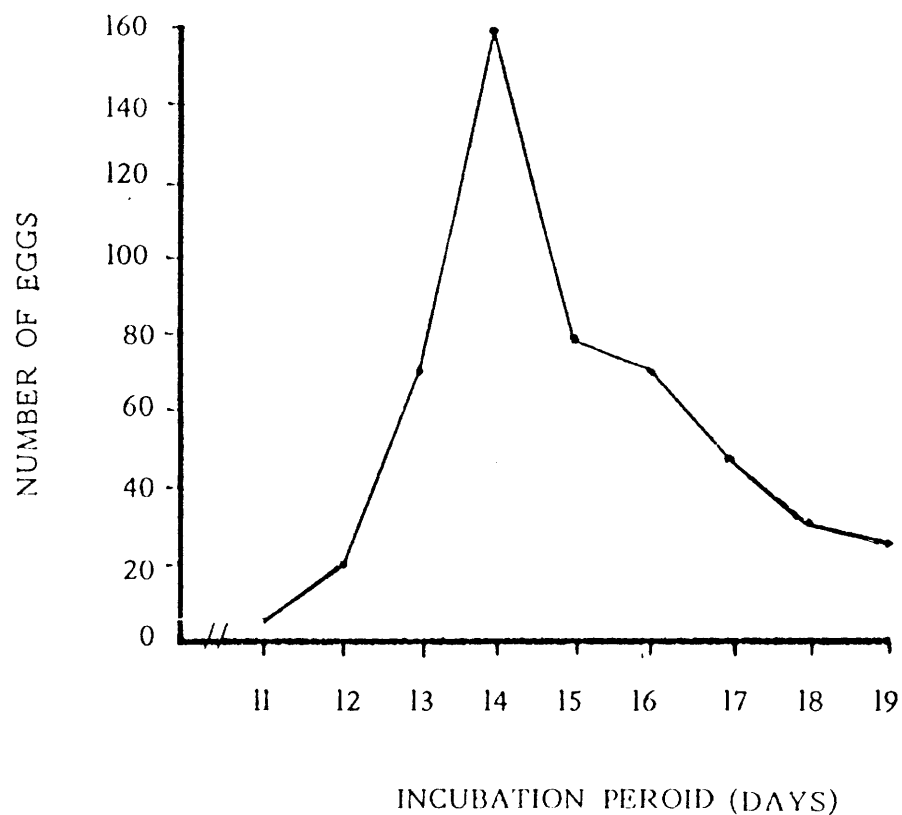


Figure 2 The number eggs hatched of sugarcane stem boring grubs, Dorysthenes buqueti Guerin and lenght of incubation period under laboratory conditions (temperature 29.95 ± 0.99 and 78.58 ± 5.05 % RH).

The larva : The newly hatched larvae burrow into the soil. They feed on roots of sugarcane or grass. The fifth instar bore into the stem of sugarcane from the base upwards. There are some faeces round an entrance hole. Larvae can damage the upper stem to a height of 20-25 cm (generally 10-15 cm). The colour of the injured plant is often yellow and it is easily broken. Normally, the larvae of D. buqueti Guerin live and molt in the soil. They stop feeding for 5-7 days before molting. The larvae are not sensitive to light, therefore they do not have a day and night pattern. They are sensitive to vibration. The development period of D. buqueti Guerin is either one or two years. A year of the developmental period 314.28 ± 64.98 days (range 262-358 days) (Table 1) where the two year life cycle takes 526.75 ± 99.89 days (range 365-617 days) (Table 2). The period of development of grubs in these two life cycles are different.

The pupa : The last instar larvae pupate in the soil. The subjects observed made pupae chambers at a depth of 40-60 cm (in Chonburi province) and at a depth of 10-20 cm (in Kanjanaburi). The chamber was ovoid with a length of 4.5-5.0 cm and a width of 4.0-4.2 cm (Fig. 1). The pre-pupal period was 6.14 ± 1.15 days (range 4-9 days) and the pupal period was 11.54 ± 1.89 days (range 9-16 days). The emerged adult stayed in the chamber for about 7-10 days. They came out and mated when they became drenched in water. The pupae are slightly yellow.

Table 1 Development of each stage of sugarcane stem boring grubs, Dorysthenes buqueti Guerin under laboratory conditions (29.95±0.99 °C, 78.58±5.05 % RH), one year life cycle.

Stage of development	Number of observation	Developmental period	
		Mean ± SD (days)	Range (days)
Egg	521	15.50 ± 3.03	11-27
Larvae :			
Instar I	18	16.67 ± 10.78	6-53
Instar II	18	27.39 ± 9.71	12-48
Instar III	18	57.67 ± 50.94	16-184
Instar IV	18	61.44 ± 40.19	18-162
Instar V	18	58.69 ± 51.90	14-196
Instar VI	18	88.85 ± 50.78	13-183
Instar VII	18	75.83 ± 12.37	61-89
Instar VIII	18	50.00 ± 25.22	24-89
Total	18	314.28 ± 64.98	262-358
Prepupa	18	6.14 ± 1.15	4-9
Pupa	18	11.54 ± 1.89	9-16
Adult : Male (♂)	10	11.25 ± 3.46	7-19
Female (♀)	10	10.70 ± 3.23	7-16
Total life cycle			
Male (♂)	8	356.25 ± 16.77	323-381
Female (♀)	8	327.50 ± 21.46	291-363
Oviposition period	22	5.45 ± 1.30	4-8

Table 2 Development of each stage of sugarcane stem boring grubs, Dorysthenes buqueti Guerin under laboratory condition (29.95±0.99 °C, 78.58±5.05 % RH), two year life cycle.

Stage of development	Number of observation	Developmental period	
		Mean \pm SD (days)	Range (days)
Larvae :			
Instar I	10	12.67 \pm 1.03	12-14
Instar II	10	30.70 \pm 3.54	23-32
Instar III	10	51.67 \pm 27.96	12-18
Instar IV	10	30.67 \pm 13.82	13-43
Instar V	10	79.17 \pm 46.31	22-144
Instar VI	10	89.50 \pm 56.14	5-169
Instar VII	10	61.50 \pm 29.82	32-105
Instar VIII	10	137.80 \pm 69.14	44-200
Instar IX	10	53.40 \pm 6.00	37-69
Total	10	526.75 \pm 99.89	365-617
Prepupa	10	6.50 \pm 1.59	4-9
Pupa	10	12.60 \pm 4.09	7-18
Adult : Male (σ)	10	12.41 \pm 5.32	7-20
Female (ϕ)	10	10.60 \pm 3.02	6-15
Total life cycle			
Male (σ)	8	562.30 \pm 92.50	394-650
Female (ϕ)	8	528.25 \pm 99.67	379-624

are slightly yellow. The smooth head extends downwards. Their length is 4.0-4.5 cm and their width is 1.5-2.0 cm.

The adults : A newly emerged adult is soft, yellow brown. They cannot crawl out of the soil until their cuticle becomes hard (after about 7-10 days). They generally emerge from the soil after rain. In Chonburi province, adults of D. buqueti Guerin appeared in between April and May. The female began to oviposit 1-2 days after mating. They mated many time in the night. The oviposition period is 5.45 ± 1.30 (range 4-8 days). The virgin females lay infertile eggs. During the day, the adult lives in the soil or leaves of cane but becomes active by night between 19.30-21.30. The males have good flying ability. However the females can fly only a short distance and they crawl in the cane field for oviposition.

The male antennae reach the wing tips. There are some yellow brown hairs on the mesosternum and metasternum, and the last segment of abdomen has yellow brown hairs.

The female antennae reach half way down to the wings. There are no hairs on the mesosternum and metasternum and the last segment of abdomen is smooth.

One year life cycle

The larva had 4-8 instars and the average stadia, were as follows : first instar 16.67 ± 10.78 days (range 6-53 days); second instar : 27.39 ± 9.71 days (range 12 to 48 days) ; third instar 57.67 ± 50.94 days (range 16-184 days) ; fourth instar 61.44 ± 40.19 days (range 18 to 162 days) ; fifth instar 58.69 ± 51.90 days (range 14 to 196 days) ; sixth instar 88.85 ± 50.78 days (range 13 to 183 days) ; seventh instar 75.83 ± 12.37 days (range 61-89 days) ; and eighth instar 50.00 ± 25.22 (range 24 to 89 days). The prepupal period was 6.14 ± 1.15 days (range 4 to 9 days) (Table 1).

The body measurement of the larva in each instar was as follows : first instar : 3.00 ± 0 mm ; second instar : 4.7 ± 0.082 mm (range 4 to 6 mm) ; third instar : 10.50 ± 0.272 mm (range 6 to 14 mm) ; fourth instar 20.10 ± 1.073 mm (range 10 to 48 days) ; fifth instar 32.89 ± 1.661 mm (range 17 to 63 mm) ; sixth instar 39.00 ± 1.442 mm (range 21 to 64 mm) ; seventh instar 45.20 ± 0.650 mm (range 38 to 53 mm) and eighth instar 55.50 ± 0.545 mm (range 50-62 mm) (Table 3).

Two year life cycle

Most larva had nine instars and the average stadia, were as follows : first instar 12.67 ± 1.03 days (range 12 to 14 days); second star 30.70 ± 3.54 days (range 23 to 32 days) ; third instar

Table 3 Body measurement of sugarcane stem boring grubs, *Dorysthenes buqueti* Guerin at various stages of development.^{1/}

Stage of development	One year life cycle		Two year life cycle	
	Body size (mm)		Body size (mm)	
	Mean \pm SD	range	Mean \pm SD	range
Egg : width	0.12 \pm 0.01	0.11-0.13	0.12 \pm 0.01	0.11-0.13
length	0.32 \pm 0.01	0.31-0.33	0.32 \pm 0.01	0.31-0.33
larva : body length				
Instar I	3.00 \pm 0	3.0-3.0	3.0 \pm 0	3.0-3.0
Instar II	4.70 \pm 0.082	4.0-6.0	6.0 \pm 0.063	5.0-7.0
Instar III	10.50 \pm 0.272	6.0-14.0	11.43 \pm 0.179	9.0-13.0
Instar IV	20.10 \pm 1.073	10.0-48.0	20.80 \pm 0.531	15.0-17.0
Instar V	32.89 \pm 1.661	17.0-63.0	27.67 \pm 1.240	15.0-46.0
Instar VI	39.00 \pm 1.442	21.0-64.0	43.80 \pm 1.588	23.0-63.0
Instar VII	45.20 \pm 0.650	38.0-53.0	52.17 \pm 1.013	37.0-67.0
Instar VIII	55.50 \pm 0.545	50.0-62.0	58.33 \pm 0.922	48.0-74.0
Instar IX	-	-	62.67 \pm 0.894	51.0-72.0

^{1/} based on 18 number of observations for one year life cycle and 10 number of observation for two year life cycle at the early stage of development

51.67 \pm 27.96 days (range 12 to 18 days) ; fourth instar 30.67 \pm 13.82 days (range 13 to 43 days) ; fifth instar 79.17 \pm 46.31 (range 22 to 144 days) ; sixth instar 89.50 \pm 56.14 days (range 5 to 169 days) ; seventh instar 61.50 \pm 29.82 days (range 32-105 days) ; eighth instar 137.80 \pm 69.14 (range 44 to 200 days) and ninth instar 53.40 \pm 6.00 days (range 37 to 69 days) (Table 2).

The body measurement at each instar, was as follows : first instar 3.00 \pm 0 mm ; second instar 6.00 \pm 0.063 mm (range 5 to 7 mm) ; third instar 11.43 \pm 0.179 (range 9 to 13 mm) ; fourth instar 20.80 \pm 0.531 mm (range 15 to 17 mm) ; fifth instar 27.67 \pm 1.24 mm (range 15 to 46 mm) ; sixth instar 43.8 \pm 1.588 mm (range 23 to 63 mm) ; seventh instar 52.17 \pm 1.013 mm (range 37 to 67 mm) ; eighth instar 58.33 \pm 0.922 mm (range 48 to 74 mm) ; and ninth instar 62.67 \pm 0.894 mm (range 51-72 mm) (Table 3).

The larval head capsules, from the cast-off exuviae of the reared larva were measured for their widths through all larval development stages to determine the growth increment of Dorysthenes buqueti Guerin. The head capsules showed a definite range having an interval between successive larval instars. The average head capsule widths in successive larval instars increased in a geometric progression with an average ratio of 1.4676 in the one year life cycle (Table 4) and 1.3978 in the two year life cycle (Table 5).

Table 4 Width of the head capsule of sugarcane stem boring grubs, *Dorysthenes buqueti* Guerin in successive larval instars ; one year life cycle.

larval instar	observed width of head capsule (mm) (O)		growth ratio of head capsule ^{1/}	Calculated of width of head capsule ^{2/} (E)	$\frac{(O-E)^2}{E}$
	mean \pm SD	range			
1 st	0.70 \pm 0.002	0.67-0.73		0.7000	0
			1.0857		
2 nd	0.76 \pm 0.004	0.70-0.85		1.0273	0.0696
			2.0395		
3 rd	1.55 \pm 0.340	1.00-2.14		1.5077	0.0012
			2.0516		
4 th	3.18 \pm 0.158	1.66-7.43		2.2127	0.4229
			1.5409		
5 th	4.90 \pm 0.187	2.90-8.70		3.2174	0.8410
			1.1429		
6 th	5.60 \pm 0.155	3.90-8.33		4.7659	0.1460
			1.2500		
7 th	7.00 \pm 0.102	5.55-7.72		6.9944	0.0000
			1.1629		
8 th	8.14 \pm 0.042	7.67-8.52		10.2650	0.4399
Sum	-	-	-	-	1.9206

Observed frequency = mean

Mean geometric growth ratio = 1.4676

It can conclude that head capsule was not significantly different

$$\chi^2 = 1.9206 \text{ df } 6$$

^{1/}Growth ratio of head capsule are calculated from mean of observed width of head capsule (mm) of succeeding instar larval/prior instar larvae

^{2/}Calculate width of head capsule = mean of growth rate of head capsule 1st instar x mean geometric growth ratio

Table 5 Width of the head capsule of sugarcane stem boring grubs, Dorysthenes buqueti Guerin in successive larval instars, two year life cycle.

larval instar	observed width of head capsule (mm) (O)		growth ratio of head capsule ^{1/}	Calculated of width of head capsule ^{2/} (E)	$\frac{(O-E)^2}{E}$
	mean \pm SD	range			
1 st	0.71 \pm 0.002	0.70-0.75		0.7100	0
			1.2254		
2 nd	0.87 \pm 0.005	0.81-0.92		0.9926	0.0151
			1.8851		
3 rd	1.64 \pm 0.025	1.16-1.82		1.3877	0.0459
			1.8963		
4 th	3.11 \pm 0.085	2.18-4.45		1.9400	0.7056
			1.4502		
5 th	4.51 \pm 1.617	2.84-6.35		2.7121	0.1919
			1.2794		
6 th	5.77 \pm 0.191	3.71-8.30		3.7915	0.0324
			1.2842		
7 th	7.41 \pm 0.165	4.20-8.56		5.3005	0.8395
			1.0972		
8 th	8.13 \pm 0.084	7.17-9.28		7.4101	0.0699
			1.0644		
9 th	8.67 \pm 0.084	7.17-9.63		10.3593	0.2755
Sum	-	-	-	-	2.1758

Observed frequency = mean

Mean geometric growth ratio = 1.3978

It can conclude that head capsule was not significantly different

$$\chi^2 = 2.1758 \quad df 7$$

^{1/}Growth ratio of head capsule are calculated from mean of observed width of head capsule (mm) of succeeding instar larval/prior instar larvae

^{2/}Calculate width of head capsule = mean of growth rate of head capsule 1st instar x mean geometric growth ratio

An analysis using the Chi-square goodness of fit test, for the mean width head capsule with on $n-2$ degree of freedom, yielded a non significant value of pooled Chi-square, indicating confirmation to Dyar's law.

A simple linear regression was fitted to determine the relationship between the head capsule width and successive larval instars. In one year life cycle, the simple regression equation was $\hat{y} = -1.23 + 1.16x$, where \hat{y} = estimated value of the width of the head capsules, x = the larval instar. The correlation coefficient (r) was 0.9899 and the contribution of the regression ($r^2 = 0.98$) was 98 per cent in one year life cycle (Fig. 3). In the two year life cycle, the regression equation was $\hat{y} = -1.12 + 1.13x$ where \hat{y} = estimated values of the width of the head capsules, x = the larval instar. The correlation coefficient (r) and the contribution of the regression was the same as in the one year life cycle (Fig. 4).

The advantage in studying the larva head capsule is that it helps in estimating the population in the field.

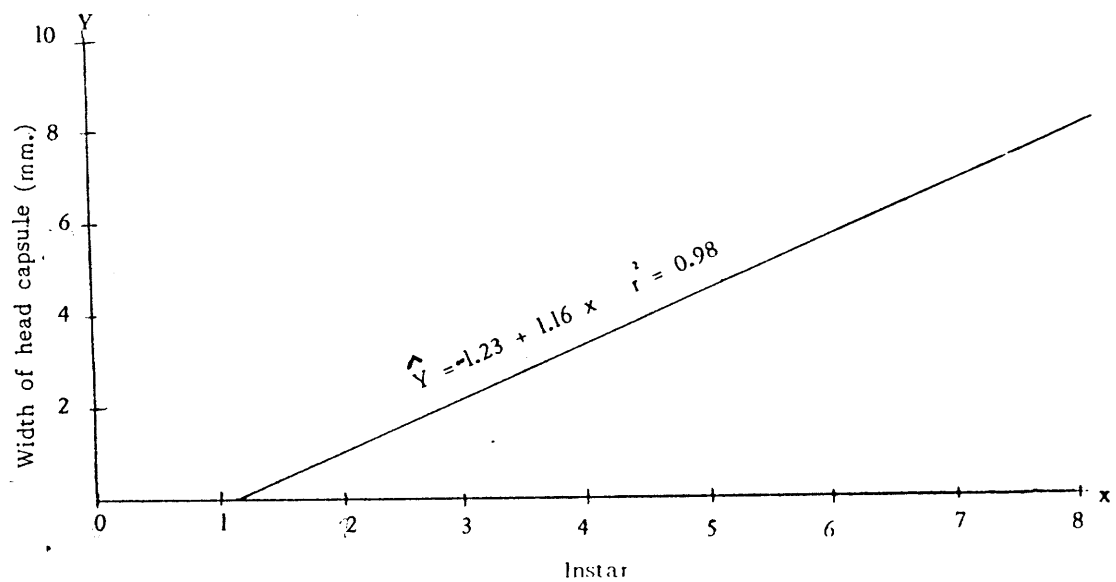


Figure 3 Relationship between the width of the head capsule and the larval instar of sugarcane stem boring grubs, Dorysthenes buqueti Guerin, one year life cycle.

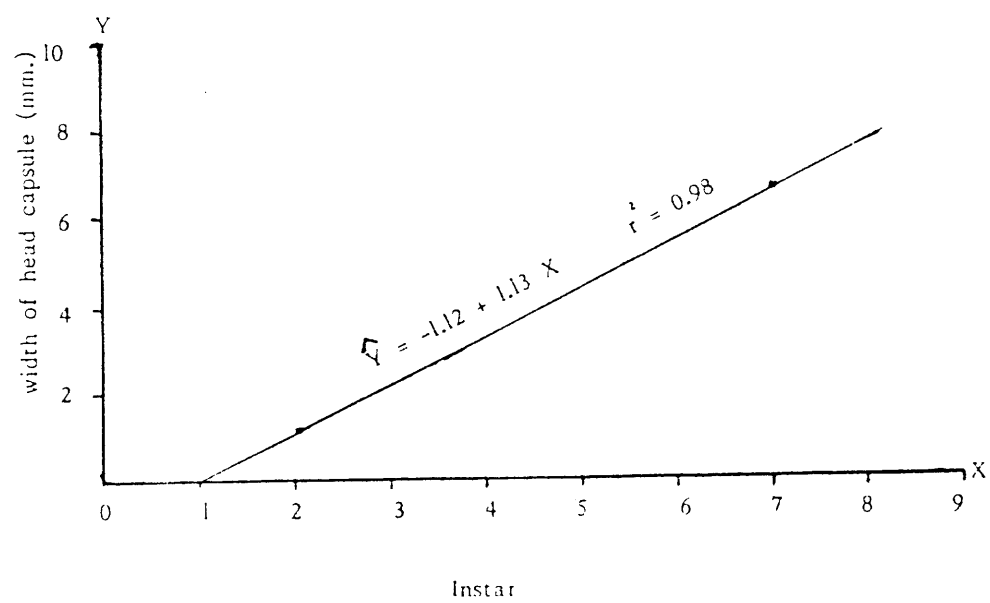


Figure 4 Relationship between the width of the head capsule and the larval instar of sugarcane stem boring grubs, Dorysthenes buqueti Guerin, two year life cycle.

2. Under field condition

The first instars of sugarcane stem boring grub were released in May, 1990, until harvest time in April, 1991 and March, 1992. The result showed that the survival rate was 10 per cent. Sixty-seven per cent had a one year life cycle and 33 per cent had a two year life cycle (Fig. 5).

To detect distribution patterns and sequential sampling for sugarcane stem boring grubs

1. Distribution pattern

The spatial distribution pattern of the stools of sugarcane infested by stem boring grub, D. buqueti Guerin was investigated between February 1989 and March 1990 in Chonburi province. The data were analyzed to determine the spatial distribution patterns of D. buqueti Guerin (Table 6 and 7). The variance and mean ratio were used as an indicator to detect the spatial distribution patterns while Morisita's index (I_m) with F value was calculated to confirm the value of variance : mean ratio. The fit was observed and the expected frequency distribution was tested by the Chi-square goodness of fit test and the Poisson distribution (Table 6 and 7). The area change of variance : mean ratio of infestation of sugarcane stem boring grub is shown in Fig 6 and 7.

Figure 5 Method of studying the life cycle of the sugarcane stem boring grubs, Dorysthenes buqueti Guerin, in field conditions, Chonburi province, March 1991 - April 1992.

1. Severe root damage by Dorysthenes buqueti Guerin has caused cane to fall under its over weight
2. Cane without Dorysthenes buqueti Guerin



Table 6 Distribution pattern of sugarcane stem boring grubs, Dorysthenes
buqueti Guerin on sugarcane at Chonburi province, February-March,
1989.

Sampling area (rai)	No. of infested stools per area	Observed infested stools	Expected of infested stools	χ^2	Index of dispersion	
					varaince mean ratio	Morisita index
0.5	0	20	16.44	49.78**	1.70	1.90
	1	36	27.95			F=12.44**
	2	11	23.76			
	3	12	13.46			
	4	3	5.72			
	5	3	1.95			
	6	3	0.55			
	7	2	0.13			
1.0	0	88	81.99	31.37**	1.25	2.24
	1	95	95.94			F=47.55**
	2	51	56.12			
	3	17	21.89			
	4	9	1.40			
	5	1	1.50			
	6	2	0.29			
	7	1	0.05			

Table 6 (Cont.)

Sampling area (rai)	No. of infested stools per area	Observed infested stools	Expected of infested stools	λ^2	Index of dispersion	
					variance mean ratio	Morisita index
2.0	0	134	141.03	14.95 ^{**}	1.05	2.17
	1	203	186.16			F=89.08 ^{**}
	2	122	122.86			
	3	38	54.06			
	4	22	17.84			
	5	6	2.92			
	6	2	1.04			
	7	1	0.20			
3.0	0	687	678.08	15.0997 ^{**}	1.14	2.09
	1	87	105.31			F=511.195 ^{**}
	2	18	8.1774			
4.0	0	1015	1014.60	1.81 ^{NS}	1.05	27.60
	1	39	40.58			F=13768.75 ^{**}
	2	2	0.81			

Table 6 (Cont.)

Sampling area (rai)	No. of infested stools per area	Observed infested stools	Expected of infested stools	λ^2	Index of dispersion	
					varaince mean ratio	Morisita index
	4	4	2.53			
	5	3	0.24			
	6	1	0.02			
8.0	0	1935	1925.78	12.84 ^{**}	1.10	3.38
	1	160	177.74			F=1675.73 ^{**}
	2	16	8.20			
	3	1	0.25			
9.0	0	2057	298.86	1127.79 ^{**}	1.31	4.57
	1	269	260.44			F=1696.71 ^{**}
	2	36	26.79			
	3	11	1.45			
	4	2	0.06			
	5	1	4.002			

Table 7 Distribution pattern of sugarcane stem boring grubs, Dorythenes
buqueti Guerin on sugarcane at Chonburi province, February-March,
1990.

Sampling area (rai)	No. of infested stools per area	Observed infested stools	Expected of infested stools	λ^2	Index of dispersion	
					varaince mean ratio	Morisita index
1.0	0	241	236.54	75.09 ^{**}	1.45	3.35
	1	36	27.95			F=207.00 ^{**}
	2	2	1.43			
	3	2	0.05			
3.0	0	768	756.13	3359.00 ^{**}	1.52	5.21
	1	95	95.94			F=695.65 ^{**}
	2	9	2.95			
	3	1	0.002			
	5	1	0.0003			
4.0	0	158	118.18	76.79 ^{**}	1.36	1.99
	1	275	258.78			F=105.45 ^{**}
	2	243	283.37			
	3	167	206.86			
	4	106	113.26			
	5	55	49.61			

Table 7 (Cont.)

Sampling area (rai)	No. of infested stools per area	Observed infested stools	Expected of infested stools	λ^2	Index of dispersion	
					varaince mean ratio	Morisita index
	5	6	3.29			
	6	1	0.16			
	7	1	0.06			
7.0	0	1423	1329.21	146.56 ^{**}	1.44	4.81
	1	285	437.99			F=431.76 ^{**}
	2	102	72.16			
	3	32	7.93			
	4	6	3.32			
8.0	0	1142	905.74	8136.49 ^{**}	1.76	3.58
	1	509	776.68			F=606.15 ^{**}
	2	249	324.62			
	3	129	91.61			
	4	55	14.39			
	5	9	3.28			
	6	10	0.46			
	7	5	0.60			

Table 7 (Cont.)

Sampling area (rai)	No. of infested stools per area	Observed infested stools	Expected of infested stools	χ^2	Index of dispersion	
					varaince mean ratio	Morisita index
	6	30	18.11			
	7	13	5.66			
	8	6	1.53			
	9	2	0.38			
	10	1	0.08			
5.0	0	1067	1044.42	563.06 ^{**}	1.24	3.05
	1	237	269.56			F=554.91 ^{**}
	2	37	34.29			
	3	7	2.99			
	4	3	0.02			
	5	1	0.009			
6.0	0	686	638.56	33.29 ^{**}	1.17	2.58
	1	530	580.09			F=358.35 ^{**}
	2	241	263.56			
	3	92	79.80			
	4	27	18.12			

Table 7 (Cont.)

Sampling area (rai)	No. of infested stools per area	Observed infested stools	Expected of infested stools	λ^2	Index of dispersion	
					varaince mean ratio	Morisita index
	8	2	0.006			
	9	2	0.0006			
9.0	0	1804	1674.89	112625.08**	1.59	2.78
	1	390	585.69			F=529.40**
	2	136	108.41			
	3	30	11.94			
	4	5	1.04			
	5	9	0.07			
	6	1	0.04			
	8	1	0.000009			

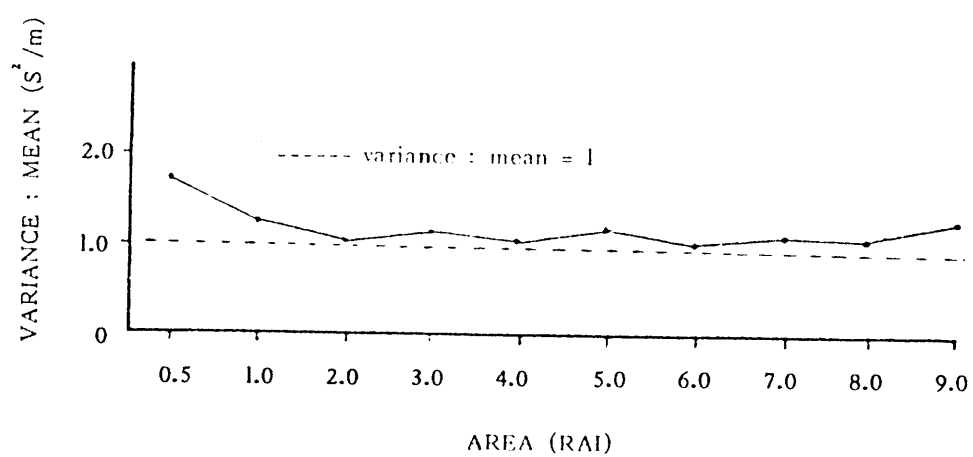


Figure 6 The relationship between variance : mean ratio values with the sizes of sampling area of sugarcane stem boring grubs, Dorysthenes buqueti Guerin at Chonburi distribution in February - March, 1989.

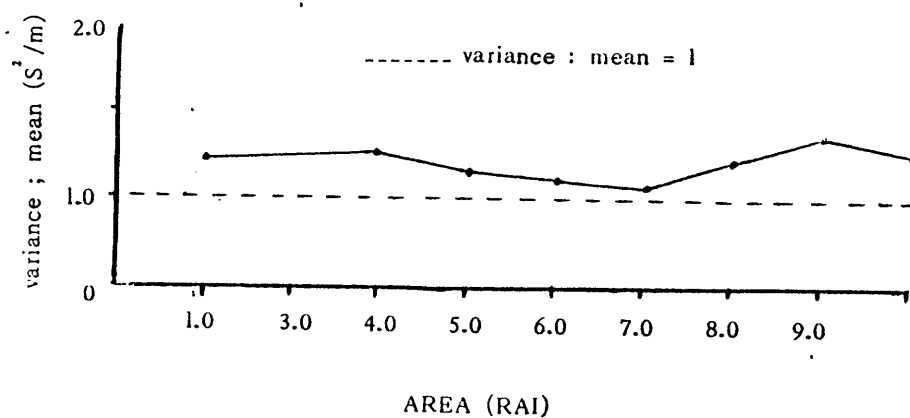


Figure 7 The relationship between variance : mean ratio values with the sizes of sampling area of sugarcane stem boring grubs, Dorysthenes buqueti Guerin at Chonburi distribution in February - March, 1990.

From the analyzed data, it was concluded that all these area were infested. The spatial distribution pattern was contagious as indicated by the high variance : mean with values of more than 1 and significantly, l_g . The Chi-square goodness of fit was significant, except for areas 4 and 6 in 1989. The distribution pattern was randomized. The Morisita's index was more than 1.3 and variance : mean ratio was more than 1. Areas 1, 2, 3, 5, 7, 9 and 10 were contagious (negative binomial).

2. Sequential sampling plan

The sugarcane stem boring grub, D. buqueti Guerin is a major insect pest of sugarcane. In order to determine the presence or absence of larva on a sample unit. A sequential sampling is especially easy to use because it does not require all the sugarcane stem boring grub to be counted on all the stalks. A sample recognition of the sugarcane stem boring grub is adequate in order to determine its presence or absence.

A comparison between the percentage of infested stalks and stools of sugarcane, showed that the relationship was not linear (Fig. 8). A simple linear regression was incorrect. The fit was polynomial. The model was $\hat{y} = 3.5912x - 0.0376x^2$ where \hat{y} = the estimated values of percentage of infested stools, x = percentage of infested stalks.

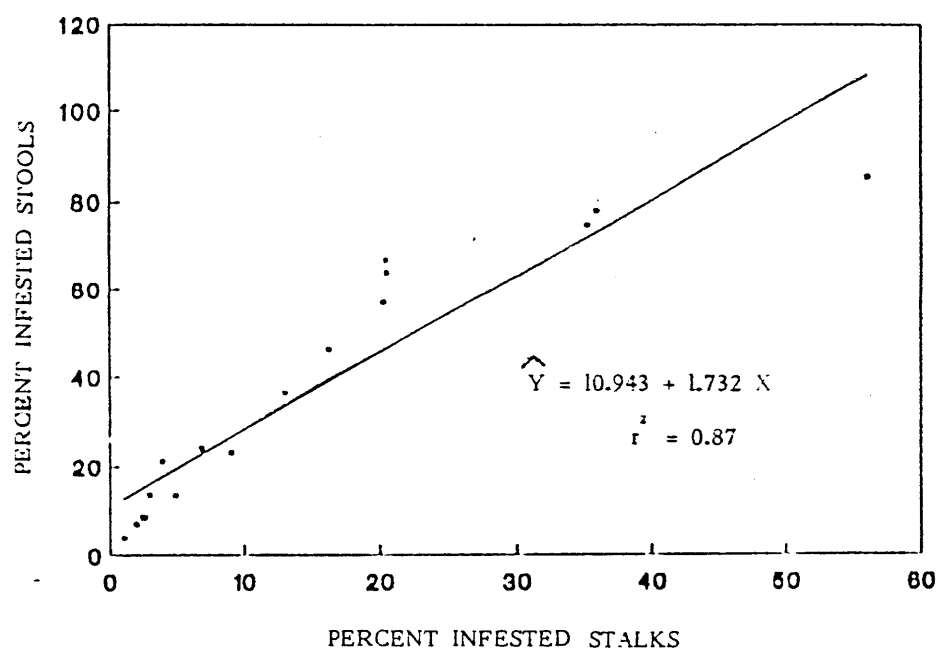


Figure 8 Correlation regression of the percentage of infested stalks and percentage of infested stools of sugarcane stem boring grubs, Dorysthenes buqueti Guerin at Chonburi province, 1989-1990.

To produce y of 4 per cent infested stools with a value of 1.127, for the percentage of infested stalks (Fig. 9) and the economic threshold of sugarcane stem boring grubs was 24 per cent stools equal to 7.23 per cent infested stalks.

The sequential sampling developed was used :

$$LSV = \text{samp} * (ET - W_2 * SE)$$

$$USV = \text{samp} * (ET + W_1 * SE)$$

where LSV = Lower stop values

USV = Upper stop values

SE = Standard error

$$W_1 = 2.07874 + 0.12105 * \ln(\text{samp}) - 0.17096 * \ln(ET)$$

$$W_2 = 1.9199 + 0.19037 * \ln(\text{samp}) + 0.34179 * \ln(ET)$$

where W_1 and W_2 were the appropriate values of the width parameter, samp = sample number (1,2...200) and ET the economic threshold expressed as a proportion between 0.01 and 0.5. The sequential sampling stop values were calculated by the following equations. Standard error $[(ET * (1-ET)/\text{samp})^{0.5}]$, $ET = 0.0723$ (7.23 % infested shoots from polynomial regression). It has been shown that these equations provide stop values for sequential sampling models that have the maximum allowable sequential errors A and B of 0.1. The results are shown in Fig. 10 and Appendix Table 1.

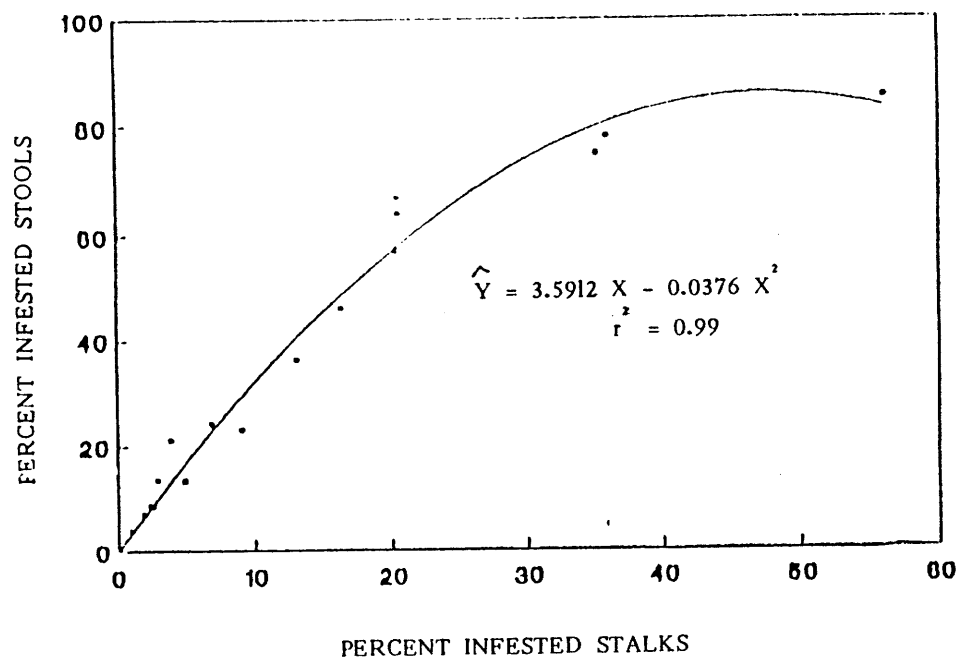


Figure 9 Correlation regression the percentage of infested stalks and the percentage of infested stools of sugarcane stem boring grubs, Dorysthenes buqueti Guerin at Chonburi province, 1989-1990.

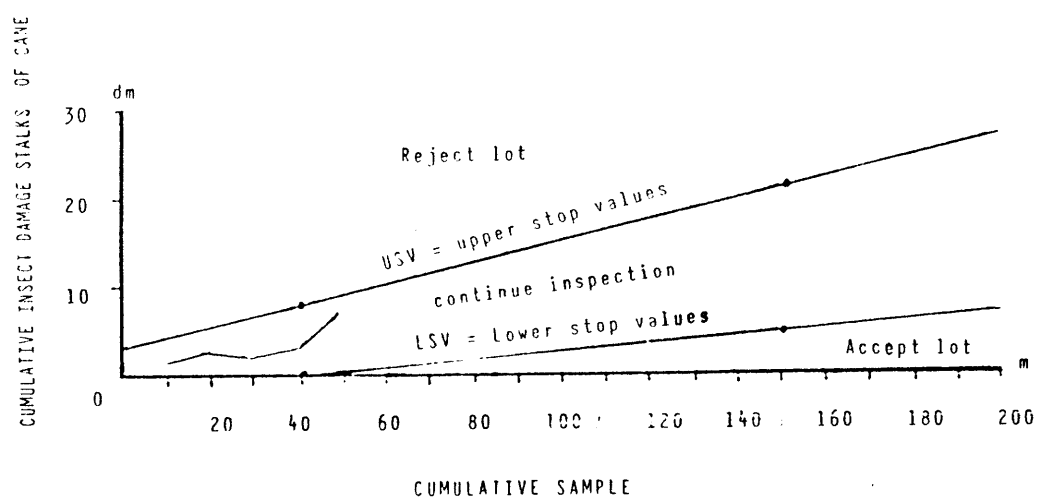


Figure 10 Sequential sampling plan for sugarcane stem boring grubs,
Dorysthenes buqueti Guerin.

Field evaluation

If the evidence gathered after inspection the 1st sample to the thirty-seventh sample was not sufficient, then no decision could be made. If however at sample 38, the cumulative infested stalks came to more than 7, then sampling could be stopped, and a decision to spray could be made. If however the cumulative infested stalks came to less than 7 at sample 38, then sampling should be continued until the cumulative figure exceeds the figure given in the USV (upper stop value). But if the lower sample values at sample 38 is 0 (zero) then no spraying is necessary. (Appendix Table 1). The two straight lines LSV and USV are drawn before inspection starts. The points (m, dm) are plotted as inspection goes on. The author continues inspecting additional units as long as the point (m, dm) lies between the lines LSV and USV. Inspection is terminated the first time that the point (m, dm) does not lie between the lines LSV and USV. If (m, dm) lies on LSV or below, the lot is accepted. If (m, dm) lies on USV or above, the lot is rejected (Fig. 10).

To survey the natural enemies of sugarcane stem boring grubs

The natural enemies of sugarcane stem boring grub in the cane field were pathogens ; Metarrhizium sp. at Chonburi province (Fig. 11) and mites, Caloglyphus sp. at Kanjanaburi province (Fig. 12).

Symtoms : Metarrhizium sp. infected larvae of sugarcane stem boring grubs, D. buqueti Guerin. After the larvae die mycelium and spore cover the larvae with green color. The percentage of infection was about 20 per cent.

Mite ; Caloglyphus sp. was an ectoparasite of larvae, pupae and adult of sugarcane stem boring grubs. They stuck in pronotum, eyes, legs, mouth, neck, prothorax and mesothorax of the sugarcane stem boring grubs. The percentage of parasitization was about 10 per cent.



Figure 11 Sugarcane stem boring grubs, Dorysthenes buqueti Guerin
infected by Metarrhizium spp.

Figure 12 Sugarcane stem boring grub Dorysthenes buqueti Gurein
infested by the mite, Caloglyphus sp.

1. Larvae
2. Pre adult
3. Adult (dorsal)
4. Adult (ventral)



To assess crop loss caused by sugarcane stem boring grubs

1. Crop loss assessment by experiment

In plant-cane of the F156 variety, the results in the treated plot were as follows : the yield was 6.97 tons/rai ; the number of stalk was 6951.92 stalks/rai ; the percentage of infested stools was 11.45 per cent ; the percentage of infested stalk was 2.53 per cent and the commercial cane sugar (CCS) was 10.63. In the untreated plot the yield was 6.15 tons/rai ; the number of stalk was 7019.23 stalks/rai ; the percentage of infested stools was 27.63 per cent ; the percentage of infested stalks was 10.21 per cent and the CCS was 12.03.

A paired t-test analysis between the treated and untreated canes produced results which were not significantly different in yield, number of stalk and CCS (Table 8).

The percentage of infested stalks and percentage of infested stools were significant and highly significant different from untreated plots. Yield has slightly loss in weight by others factors such as the climatic and epidaphic.

Table 8 comparative yields from treated and untreated plots of F156 variety plant cane at Chonburi province November-April, 1989-1990.

Paired plots no.	<u>Yield (tons/rai)</u>		Deviation from		d^2
	Treated X_1	Untreated X_2	Difference	mean of difference (d)	
1	3.92	7.30	-3.38	-4.20	17.64
2	5.34	7.01	-1.67	-2.49	6.20
3	11.47	5.32	6.15	5.33	28.41
4	3.59	3.33	0.26	-0.56	0.31
5	10.45	6.94	3.51	2.69	7.24
6	9.78	7.13	2.65	1.83	3.35
7	8.90	5.91	2.99	2.17	4.71
8	2.28	6.23	-3.95	-4.77	22.75
Sum	55.73	49.17	6.56		90.61
Mean	6.97	6.15	0.82		

$$S = \sqrt{\frac{d^2}{n-1}} = 3.60$$

$$Sd = \frac{S}{\sqrt{n}} = 1.27$$

$$t = 0.6456^{NS} \quad df \ 7 \ (p\text{-value} = 0.2310)$$

In the field experiment, nematodes were found namely, Tylenchorhynchus sp., Pratylenchus sp., Meloidogyne sp., Helicotylenchus sp., Hoplolaimus sp., Paratrichodorus sp., Rotylenchulus sp. and Criconebella sp. (Table 9 and Fig. 13, 14). The rate of infestation was about 3,588 per 500 grams of soil in treated cane and 1,710 per 500 grams soil sample in untreated cane. The correlation between sugarcane yield and the number of nematode in both the treated and untreated plot was not significant. The correlation coefficient (r) were -0.499 and 0.15 respectively in treated and untreated cane. Birchfield, 1984 reported that the threshold density of Tylenchorhynchus spp. was 500 per 450 cubic centimetre of soil.

Crop loss assessment of cane from nematode was 23.70 per cent in ratoon cane (F-156 variety) and 17.39 per cent in plant cane (U-Thong I variety) (Table 10).

In plant cane, U-Thong I variety, the results in treated cane were as follows the yield of sugarcane was 6.28 tons/rai ; the number of stalk was 8,935.77 stalks/rai; the percentage of infested stools were 7.53 per cent ; the percentage of infested stalks was 2.01 per cent and the CCS was 10.73. In the untreated plot the yield was 4.0 tons/rai ; the number of stalk was 6,916.54 stalks/rai ; the percentage of infested stools was 13.52 per cent ; the percentage of infested stalks was 5.09 per cent and the CCS was 10.64

Table 9 The number of nematode genera found in plant cane F156 variety and their percentage at Chonburi province during the month of February-April, 1989-1990.

No.	Nematode genera	Percentage of nematode found in 500 grams soil
1.	<u>Tylenchorhynchus</u> sp.	52.13
2.	<u>Pratylenchus</u> sp.	17.92
3.	<u>Meloidogyne</u> sp.	13.65
4.	<u>Helicotylenchus</u> sp.	8.91
5.	<u>Hoplolaimus</u> sp.	3.79
6.	<u>Paratrichodorus</u> sp.	2.18
7.	<u>Rotylenchulus</u> sp.	0.95
8.	<u>Criconemella</u> sp.	0.47
Total		100.00

Figure 13 Visual morphological differences of major nematode genera found associated on the planting assess of sugarcane F156 variety.

1. Tylenchorhynchus sp.
2. Pratylenchus sp.
3. Hoplolaimus sp.



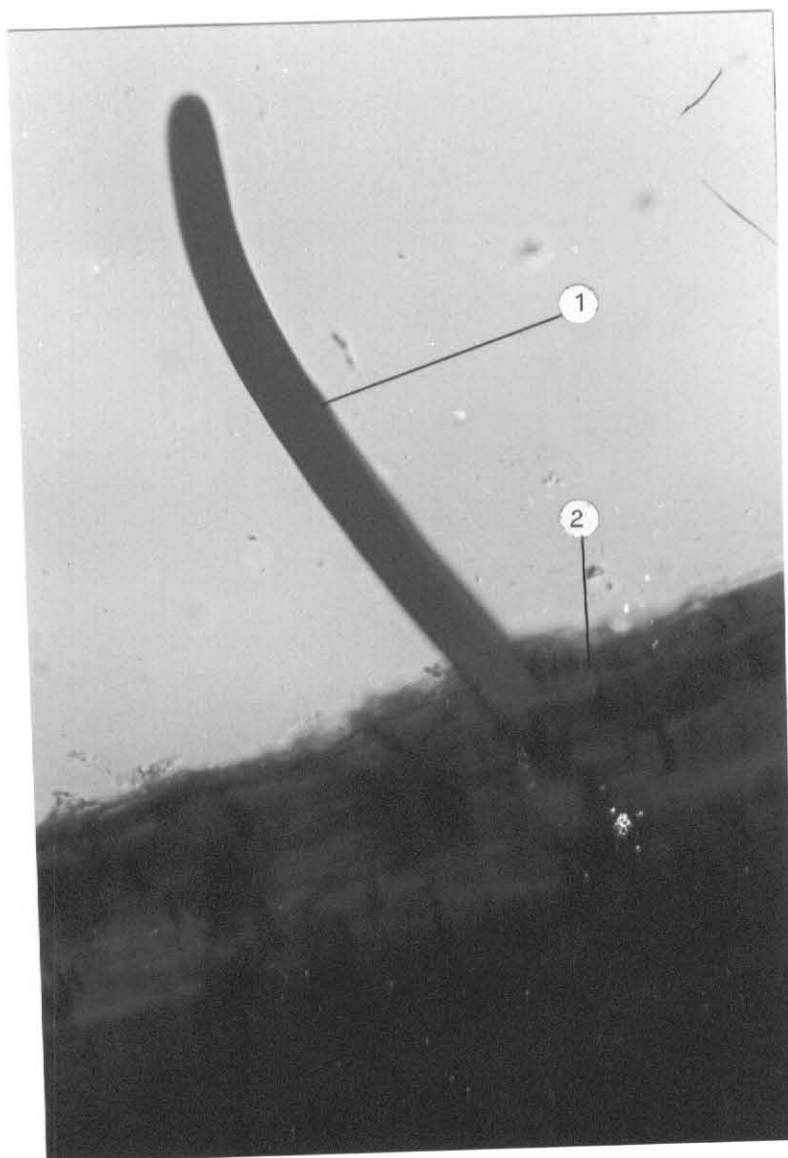


Figure 14 The infestation of nematode Hoplolaimus sp. in the sugarcane root.

1. Nematode

2. Root of sugarcane

Table 10 Comparative yield loss of sugarcane by nematode in plant cane (U-Thong 1) and ratoon cane (F156), Choburi province, April 1991.

No.	Plant cane (U-Thong 1) yield/stalk (kg)		ratoon cane (F-156) yield/stalk (kg)	
	Treated ^{1/}	Untreated	Treated ^{1/}	Untreated
1	1.22	0.78	0.45	0.35
2	1.14	0.89	0.46	0.17
3	1.11	0.98	0.48	0.27
4	1.13	1.09	0.45	0.35
5	1.23	0.99	0.48	0.40
6	1.25	0.64	0.45	0.20
7	1.28	0.78	0.45	0.45
8	1.08	0.84	0.44	0.50
9	0.91	0.62	0.48	0.47
Sum	10.35	8.55	4.14	3.159
Mean	1.15	0.95	0.46	0.351
% Yields loss		17.39	23.70	

^{1/}Treated with oxamyl 24 % LC at a rate of 18 litres/rai

A t-test analysis between the treated and untreated cane produced results which were significantly different for the yield of sugarcane, the number of stalk, the percentage of infested stools and CCS values were not significantly different. Yield reduced by 36.31 per cent (Table 11).

Ratoon cane : The result in the treated plot were as follows : yield 4.33 tons/rai ; number of stalks 6,923.08 stalks/rai; percentage of infested stalks 0.58 per cent ; percentage of infested stools 2.85 per cent ; and CCS 8.76. The untreated plot the result yielded 2.13 tons/rai ; number of stalks 4,865.38 stalks/rai ; percentage of infested stalks 19.40 per cent ; percentage of infested stools 22.72 per cent and CCS 8.99.

The t-test analysis of the yield and percentage of infested stalks were significantly different. Percentage of infested stools and CCS were not significantly different. Yield was reduced by 50.81 per cent (Table 12).

The low yield of 4.33 ton/rai and 2.13 ton/rai given above, might have been due to drought or other casual factor that were unknown.

Table 11 comparative yields from treated and untreated plots U-Thong 1 variety plant cane at Chonburi province March-April, 1989-1991.

Paired plots no.	<u>Yield (tons/rai)</u>		Difference	Deviation from	
	Treated X_1	Untreated X_2		mean of difference (d)	d^2
1	4.51	3.26	1.25	-1.03	1.06
2	6.23	3.00	3.23	0.95	0.90
3	8.53	4.48	4.05	1.77	3.13
4	4.78	1.66	3.12	0.84	0.71
5	4.90	5.89	-0.99	-3.27	10.69
6	8.72	5.69	3.03	0.75	0.56
Sum	37.67	23.98	13.69		17.05
Mean	6.28	4.00	2.28		

$$\text{Yield loss} = \frac{\bar{X}_1 - \bar{X}_2}{\bar{X}_1} \times 100 = 36.31 \%$$

$$S = \sqrt{\frac{d^2}{n-1}} = 1.85$$

$$S_d = \frac{S}{\sqrt{n}} = 0.76$$

$$t = 3.00^* \quad \text{df } 5 \quad (\text{p-value} = 0.0415)$$

*significantly different at 5 % level

Table 12 comparative yields from treated and untreated plots of F156 variety ratoon cane at Chonburi province March-April, 1990-1991.

Paired plots no.	Yield (tons/rai)		Deviation from		d ²
	Treated X ₁	Untreated X ₂	Difference	mean of difference (d)	
1	3.08	1.23	1.85	-0.28	0.08
2	5.30	2.37	2.93	0.80	0.64
3	8.22	2.78	5.44	3.31	10.96
4	2.33	1.35	0.98	-1.15	1.32
5	7.03	2.98	4.05	1.92	3.69
6	5.20	2.77	2.43	0.30	0.09
7	2.38	1.68	0.70	-1.43	2.04
8	1.10	1.85	-0.75	-2.88	8.29
Sum	34.64	17.01	17.62		27.11
Mean	4.33	2.13	2.20		

$$\text{Yield loss} = \frac{\bar{X}_1 - \bar{X}_2}{\bar{X}_1} \times 100 = 50.81 \%$$

$$S = \sqrt{\frac{d^2}{n-1}} = 1.97$$

$$Sd = \frac{S}{\sqrt{n}} = 0.696$$

$$t = 3.01^* \quad \text{df } 7 \quad (\text{p-value} = 0.045)$$

*significantly different at 5 % level

2. A survey of crop loss assessment

A survey of crop loss showed that the sugarcane stem boring grub attacked ratoon cane more than plant cane as 46 of the 150 stools of plant cane were free from infestation compared with 17 out of 150 in the case of ratoon cane. The number of sugarcane stem boring grubs was 1-6 grubs per stool in plant cane and 1-12 grubs per stool in ratoon cane (Table 13, 14). Percentage of infestation was between 15 and 95 per cent and had some influence on sugarcane yield. There was a strong negative correlation between yield and percentage of infestation (Table 15, 16).

Plant cane : Simple regression was used to study relationship between the yield and the percentage of infestation. In the regression equation, ($\hat{y} = 0.8312 - 3.1719x$), where \hat{y} = the estimated value of yield, x = percentage of infestation, the contribution of the regression ($r^2 = 0.66$) was 66 per cent (Table 14). Similarly it was also found that the percentage of infestation had a bearing on the reduction in yield. When the percentage of infestation increased there was yield decrease. The correlation coefficient (r) was 0.82 and the contribution of regression ($r^2 = 0.67$) was = 67 per cent with of regression was equation $\hat{y} = 13.4884 + 0.3319x$ (Fig. 15).

Table 13 The number of sugarcane stem boring grubs, Dorysthenes buqueti Guerin on average yield/plant (kg) and yield reduction of plant cane due to sugarcane stem boring grubs at Chonburi province, February-April, 1989-1990.

No. of stem boring grubs X	No. of plant (frequency)	Average yield per plant (kg) y	yield(kg) reduction P (%)
0	46	0.96	-
1	32	0.68	29.17
2	32	0.67	30.21
3	21	0.66	31.25
4	11	0.74	22.92
5	5	0.66	31.25
6	11	0.56	41.67
$r = 0.72^{NS}$			$r = 0.52^{NS}$

The correlation coefficient between the number of sugarcane stem boring grub and average yield per plant was 0.72^{NS} .

The correlation coefficient between the number of sugarcane stem boring grub and per cent yield reduction was 0.52^{NS} .

Table 14 The percentage of injury of sugarcane stem boring grubs, Dorysthenes buqueti Guerin and damage yield/plant (kg) on plant cane variety F156 at Chonburi province during the month of February-April, 1989-1990.

% injuries X	No. of plant (frequency)	Average yield per plant (kg) y	yield(kg) reduction P (%)
0	46	0.96	-
5	0	0	-
15	9	0.73	23.96
25	12	0.70	27.08
35	14	0.65	32.29
45	25	0.67	30.21
55	14	0.60	37.50
65	9	0.69	28.13
75	7	0.57	40.63
85	0	0	-
95	14	0.58	39.58
$r = -0.81^{**}$ $r = -0.82^{**}$			

The correlation coefficient between the percentage of injured and average yield per plant was -0.81^{**}

The correlation coefficient between the percentage of injuries and average yield per plant was -0.82^{**} .

Table 15 The percentage of injury of sugarcane stem boring grubs, Dorysthenes buqueti Guerin and damage yield/plant(kg) on ratoon cane variety F156 at Chonburi province, during the month of April-March, 1990-1991.

% injuries X	No. of plant (frequency)	Average yield per plant (kg) y	yield(kg) reduction P (%)
0	17	0.87	-
5	0	0	-
15	13	0.77	11.49
25	9	0.45	48.28
35	13	0.53	39.08
45	9	0.50	42.53
55	17	0.53	39.08
65	25	0.49	43.87
75	21	0.43	50.57
85	9	0.44	49.43
95	17	0.38	56.32
		$r = -0.83^{**}$	$r = 0.73^*$

The correlation coefficient between the percentage of injuries and average yield per plant was -0.83^{**} .

The correlation coefficient between the percentage of injuries and average yield yield reduction was -0.73^* .

Table 16 The number of sugarcane stem boring grub, Dorysthenes buqueti Guerin and damage yield/plant (kg) ratoon cane variety F156 at Chonburi province during the month of April-March, 1990-1991.

No. of stem boring grubs X	No. of plant (frequency)	Average yield per plant (kg) y	yield(kg) reduction P (%)
0	17	0.87	-
1	10	0.67	22.99
2	0	0	-
3	10	0.79	9.20
4	5	0.50	42.53
5	10	0.57	34.48
6	40	0.41	52.87
7	15	0.49	43.68
8	5	0.53	39.08
9	15	0.48	44.83
10	5	0.46	47.13
11	0	0	-
12	10	0.44	49.43
$r = 0.79^{**}$			$r = 0.71^*$

The correlation coefficient between the number of sugarcane stem boring grub and average yield per plant was 0.79^{**} .

The correlation coefficient between the number of sugarcane stem boring grub and per cent yield reduction was 0.71^* .

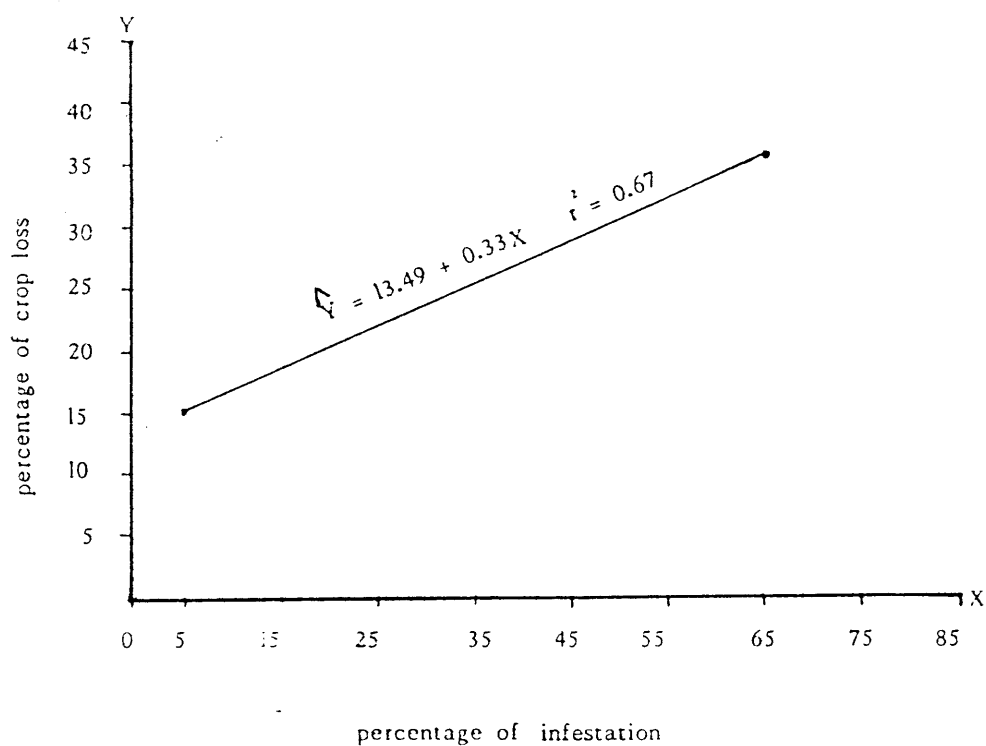


Figure 15 The relationship between the percentage of crop loss of sugarcane stem boring grubs, Dorysthenes buqueti Guerin and percentage infestation in plant cane at Chonburi province, February-April, 1989-1990.

Simple regression was used to study relationship between the yield and the number of sugarcane stem boring grub. The regression equation was $\hat{y} = 13.58 + 4.35x$ where x = number of sugarcane stem boring grub and \hat{y} = the estimated value of yield. The correlation coefficient (r) was 0.72^{NS} and the contribution of regression ($r^2 = 0.52$) was 52 per cent (Table 13). It was found that the number of sugarcane stem boring grub had a bearing on the reduction in yield. When the number of sugarcane stem boring grubs increased there was a decrease in percentage of yield. The correlation coefficient (r) being 0.72 , the contribution of regression ($r^2 = 0.52$) was 52 per cent with coefficient of regression $\hat{y} = 13.58 + 4.35x$, x = number of sugarcane stem boring grub and \hat{y} = the estimated value of percentage of yield reduction (Fig 16).

Ratoon cane : Simple regression was used to study relationship between the yield and the percentage of infestation. The result was the same as in plantcane. The regression equation was $y = 0.74 - 4.17x$. The correlation coefficient (r) was 0.83^{**} and the contribution of regression ($r^2 = 0.69$) was 69 per cent (Table 15 and Fig. 17). The regression equation (yield and number of sugarcane stem boring grubs) was $\hat{y} = 10.7522 - 0.0318x$. The correlation coefficient (r) was 0.79^{**} and the contribution of regression ($r^2 = 0.62$) was 62 per cent (Table 16). The number of sugarcane stem boring grub had a bearing on the yield reduction (Fig. 18).

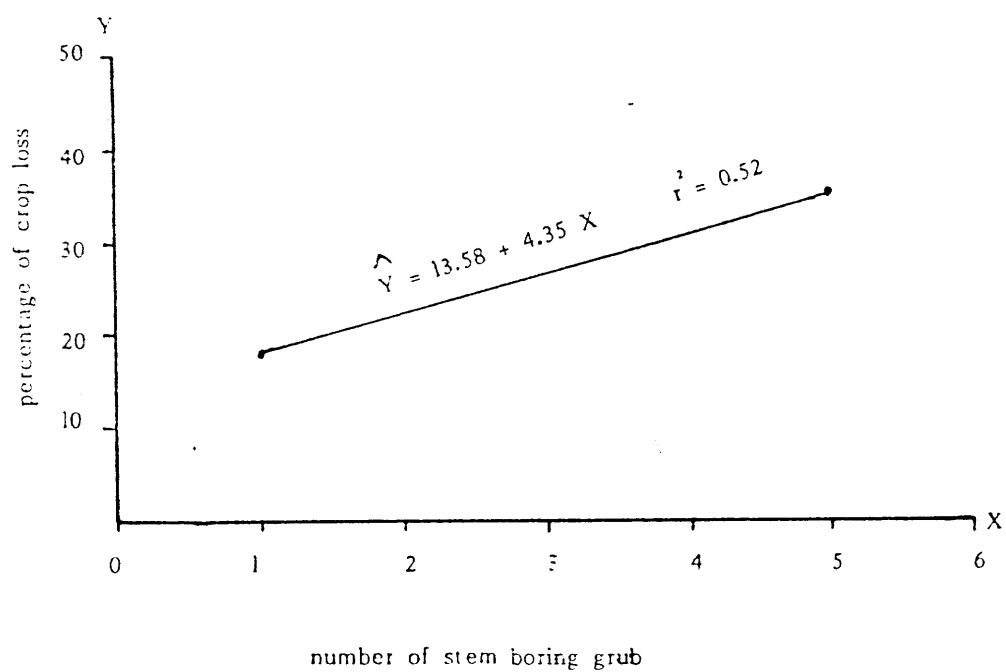


Figure 16 The relationship between the percentage of crop loss and number of sugarcane stem boring grubs Dorysthenes buqueti Guerin in plant cane at Chonburi province, February-April, 1989-1990.

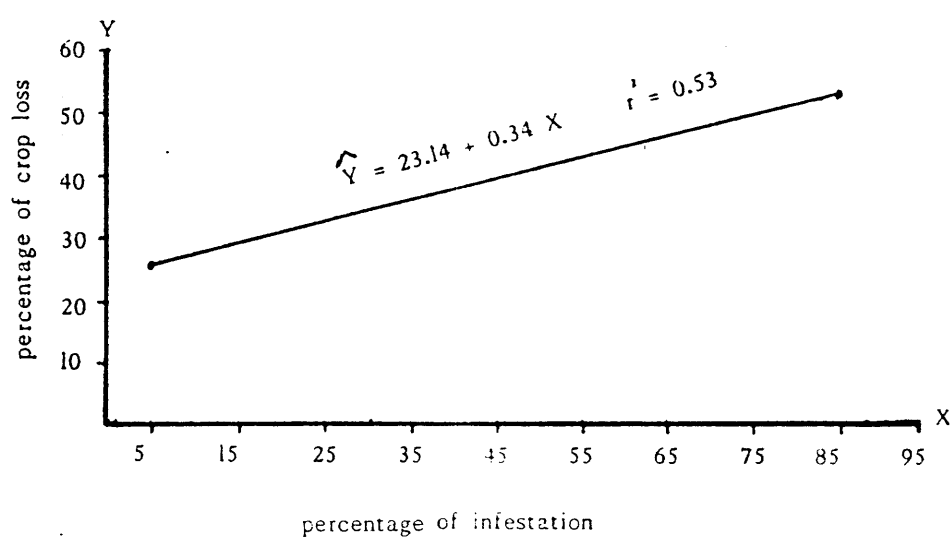


Figure 17 The relationship between the percentage of crop loss and percentage of infestation in ratoon cane at Chonburi province, April-March, 1990-1991.

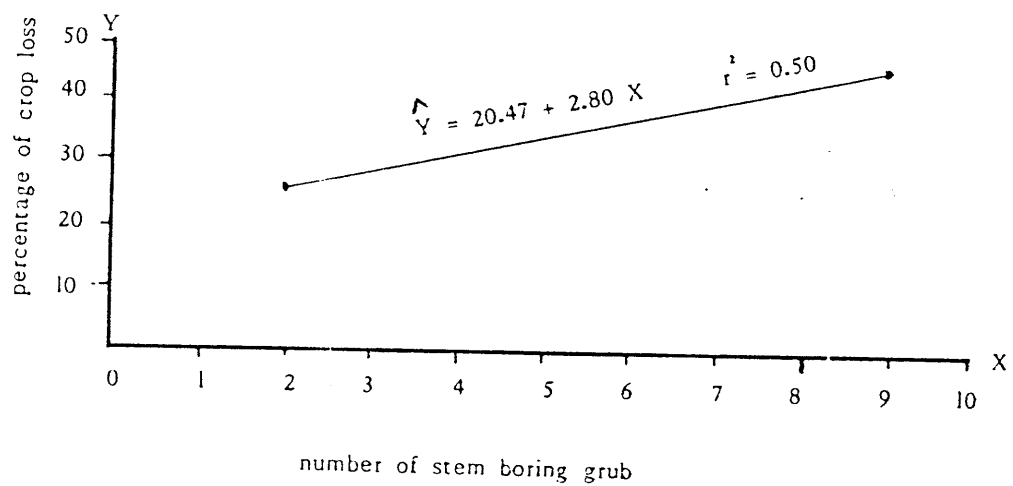


Figure 18 The relationship between the percentage of crop loss and number of sugarcane stem boring grubs Dorysthenes buqueti Guerin on ratoon cane at Chonburi province, April-March, 1990-1991.

Correlation between the number of stalk the number of stalk injured, the number of sugarcane stem boring grub, the percentage of infested stalks and yield of sugarcane. The results showed that yield depended on the number of stalk in plant cane and ratoon cane (Table 17 and 18).

To compare the efficiency of some insecticides in the control of sugarcane stem boring grubs

Trial 1 : In plant cane F156 results showed that the percentage of infested stools and percentage of infested stalks were significant. The percentage of infested stalks in cane treated by chlordane was 0.20 per cent and that treated by endosulfan + BPMC was 2.86 per cent. Check treatment showed an infestation of 33.13 per cent, but the number of stalk, yield and CCS were not significant. Chlordane 72 % EC at a rate of 700 millilitre/rai. and endosulfan + BPMC 4.5 % G at a rate of 5 kilograms/rai were effective in controlling sugarcane stem boring grubs in the field. (Table 19, Appendix Table 2-6 and Fig. 19, 20).

Table 17 Correlation coefficient (r) among yield (X_1), number of stalks (X_2), the number of stalk injured (X_3), the number of sugarcane stem boring grubs (X_4) and the percentage of infested stalks (X_5) in plant cane at Chonburi province, April-March, 1990-1991.

Variable	X_1	X_2	X_3	X_4	X_5
X_1	1.00				
X_2	0.48*	1.00			
X_3	0.06 ^{NS}	0.34 ^{NS}	1.00		
X_4	0.23 ^{NS}	0.34 ^{NS}	0.51 ^{NS}	1.00	
X_5	-0.32 ^{NS}	-0.43 ^{NS}	0.60 ^{NS}	0.19 ^{NS}	1.00

* = significantly different at the 5 % level

NS = not significantly different

Table 18 Correlation coefficient (r) among yield (X_1), number of stalks (X_2), the number of stalk injured (X_3), the number of sugarcane stem boring grub (X_4) and the percentage of infested stalks (X_5) in ratoon cane at Chonburi province, April-March, 1990-1991.

Variable	X_1	X_2	X_3	X_4	X_5
X_1	1.00				
X_2	0.83**	1.00			
X_3	0.51 ^{NS}	0.58 ^{NS}	1.00		
X_4	0.51 ^{NS}	0.49 ^{NS}	0.80 ^{NS}	1.00	
X_5	0.23 ^{NS}	0.27 ^{NS}	0.87 ^{NS}	0.62 ^{NS}	1.00

** = significantly different at the 1 % level

NS = not significantly different

Table 19 Yield, number of stalks, percentage infested stalks and percentage of infested stools in trial 1, plant cane F156 at Chonburi province, November-February, 1989-1990.

Insecticides	No. of stalks per rai	Yield tons/rai	% infested stalks	% infested stools	Commercial cane sugar (CCS)
Tefluthrin	6980.77 a	6.44 a	11.66 c	44.89 c	10.91 a
Endosulfan+BPMC	6269.23 a	5.92 a	2.86 b	17.66 b	9.12 a
Chlorpyrifos	4875.00 a	4.09 a	9.44 c	44.46 c	9.02 a
Turbufos	6932.69 a	6.02 a	13.59 c	36.60 bc	10.25 a
Chlordane	8019.23 a	8.69 a	0.20 a	8.57 a	11.36 a
Check	3605.77 a	3.28 a	33.13 c	53.06 c	10.37 a

Means followed by the same letter in a column are not significantly different at the 5 % level by DMRT.

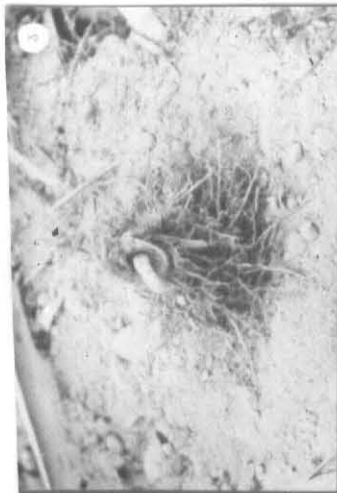
Figure 19 Sugarcane field conditions with some insecticides.

- | | |
|----------------------|-----------------|
| 1. Chlordane | 2. Terbufos |
| 3. Tefluthrin | 4. Chlorpyrifos |
| 5. Endosulfan + BPMC | 6. Check |



Figure 20 Sugarcane field infested by sugarcane stem boring grubs
Dorysthenes buqueti Guerin.

1. Infested stool
2. After cutting : note the holes in the stools
3. Larva of stem boring grup in the hole in the stools
4. Infested stalks : note the holes
5. Infested cane in the field



Trial 2 : In plant cane F140 the results showed that the percentage of infested stalks was significant and percentage of infested stalks treated in chlordane was 1.45 per cent while that treated with endosulfan + BPMC at a rate of 3, 5 and 7 kilograms/rai were 4.41, 2.99 and 3.53 per cent respectively. Check showed an infestation of 9.5 per cent. The yield, the number of stalk and the percentage of infested stools were not significant. Chlordane 72 % EC at a rate of 700 millilitre/rai and endosulfan + BPMC 4.5 % G at a rate of 3, 5 and 7 kilograms/rai were effective in controlling sugarcane stem boring grubs (Table 20).

Trial 3 : In ratoon cane F156 the results showed that the percentage of infested stools and the percentage of stalks were significant and the percentage of infested stalks in cane treated by Chlordane was 1.44 per cent that treated by endosulfan + BPMC at a rate of 5 kilograms/rai was 1.49 per cent. Check showed an infestation of 24.31 per cent. The yield, the number of stalks were not significant. Chlordane 72 % EC at a rate of 700 millilitre/rai and endosulfan + BPMC 4.5 % G at a rate of 5 kilograms/rai were effective in controlling of sugarcane stem boring grubs.

Table 20 Yield, number of stalks, percentage infested stalks and percentage of infested stools in trial 2, plant cane F140 at Chonburi province, April-March 1990-1991.

Insecticides	No. of stalks per rai	Yield tons/rai	% infested stalks	% infested stools	Commercial cane sugar (CCS)
Tefluthrin	7673.08 a	3.75 a	10.73 c	21.12 a	14.54 a
Endosulfan+BPMC (3 kgs/rai)	7183.69 a	4.16 a	4.41 b	10.81 a	14.24 a
Endosulfan+BPMC (5 kgs/rai)	8423.08 a	4.11 a	2.99 ab	12.07 a	14.24 a
Endosulfan+BPMC (7 kgs/rai)	7586.54 a	4.81 a	3.53 ab	10.99 a	14.18 a
Chlordane	7403.84 a	4.89 a	1.45 a	5.15 a	15.25 a
Check	7625.00 a	3.69 a	9.55 c	18.30 a	13.79 a

Means followed by the same letter in a column are not significantly different at the 5 % level by DMRT.

The results of three trials to determine the efficiency of insecticide in controlling sugarcane stem boring grubs in sugarcane fields showed that chlordane and endosulfan + BPMC were effective (Table 21 and Appendix Table 6-11).

To evaluate the control of the sugarcane stem boring grub by pitfall traps

In Chonburi province, the results showed that the sugarcane stem boring grub, D. buqueti Guerin began to fall into pitfall traps 10 days after the first rainfall. Eighty one sugarcane stem boring grub adults were found in the pitfall traps : Forty three adults on the rows and 38 adult inter rows. There were 46 males and 35 females and the ratio of male to females was 1.3 : 1 in plant cane. The result in ratoon cane were the same as in plant cane. The total number of adults in pitfall traps was 403 ; of which 273 were males and 130 were females. On the rows there were 250 adults, and in the inter rows there were 153 adults. The ratio of males to females was 2.1 : 1.

In Prachaub Kerikhan province, the results were the same as in Chonburi province. The total number of adults in the pitfall trap was 785 ; of which 412 were males and 373 were females. The ratio of male to females was 1.1 : 1. On the rows of ratoon cane there were 347 adults and inter rows there were 438 adults.

Table 21 Yield, number of stalks, percentage infested stalks and percentage of infested stools in trial 3, ratoon cane F156 at Chonburi province, April-March 1990-1991.

Insecticides	No. of stalks per rai	Yield tons/rai	% infested stalks	% infested stools	Commercial cane sugar (CCS)
Tefluthrin	2826.92 a	1.12 a	35.05 d	30.06 d	9.23 a
Endosulfan+BPMC (3 kgs/rai)	3807.69 a	2.00 a	8.78 c	16.17 bcd	10.01 a
Endosulfan+BPMC (5 kgs/rai)	5519.23 a	2.29 a	1.49 ab	2.71 ab	8.89 a
Endosulfan+BPMC (7 kgs/rai)	3855.77 a	1.44 a	3.93 b	11.93 bc	8.70 a
Chlordane	6711.54 a	3.55 a	1.44 a	0.54 a	8.14 a
Check	3269.32 a	1.29 a	24.31 d	29.49 cd	8.71 a

Means followed by the same letter in a column are not significantly different at the 5 % level by DMRT.

From these field experiments, the results showed that the number of male sugarcane stem boring grub was more than females. Behavior of adults :- they walked to mate and laid their eggs in the sugarcane field. The ratio of male to female was 1.3 : 1 in plant cane and 1.1-2.1 : 1 in ratoon cane (Fig. 21).



Figure 21 Pitfall trap for control of the sugarcane stem boring grubs, Dorysthenes buqueti Guerin.

DISCUSSION

Sugarcane stem boring grubs, Dorysthenes buqueti Guerin is a major pest of sugarcane in the North-east, East and West of Thailand. Larva infested sugarcane remained in the field for an average of 9-18 months. They live and eat in the soil until they pupate. Adults emerge from the soil to mate and lay their eggs in the soil. They have one year and two year life cycles. Chieng (1982) found that the life cycle of D. walkeri (waterhouse) was two years. They over winter in the soil. In Thailand, the one year life cycle has 4-8 instars. The total period of development is 314.28 ± 64.98 days. This is similar to the report of Charaensern (1982). The two year life cycle has 9 instars and the total development period is 526.75 ± 99.89 days.

A problem of rearing sugarcane stem boring grub is mites, Caloglyphus sp. It feeds on the body of sugarcane stem boring grubs until the larvae die. Thus feeding cane stalks should be changed every 3 days.

A detection of distribution patterns showed that distribution patterns the spatial distribution of sugarcane stem boring grub from 10 fields in 1989 and 8 fields in 1990 were contagious, the variance to : mean ratio was more than 1 (Southwood, 1978) and the Morisita index was more than 1.3 (Theunissen, 1982). A random test

using the Chi-square goodness of fit method in 2 areas in 1989 was not significant. This means that the distribution pattern was not contagious. It was random. But the variance : to mean ratio and the Morisita index test were significant so the chance of distribution was both random and contagious.

A sequential sampling plan showed that the stop line generated through the sequential interval procedure was not linear (Legg et al., 1992). The economic threshold was 0.0723 (24 per cent stool = 7.23 per cent stalk, quadratic equation) and error A and B were 0.1. Error A occurred when growers sprays sugarcane when the stem boring grub population is low or non existent (sprays unnecessarily). Error B occurred when growers did not spray sugarcane when stem boring grub infestations were high (he failed to spray).

This sequential sampling plan uses above was effective in reducing time and expense by 60-90 per cent. It was also easy and quick to apply.

These are two natural enemies of sugarcane stem boring grubs in the cane field. The first is the mite, Caloglyphus sp. They infest larvae, pupae, and adults of sugarcane stem boring grub. The percentage of infestation was 10 per cent in Kanjanaburi province. The second is fungus, Metarrhizium sp. It was found in

the late rainy season and the percentage of infestation was 20 per cent in Chonburi province.

Crop loss assessment in plant cane F156 was studied using pairs of untreated cane and cane treated with chlordane 700 millilitre/rai. It was found that the reduction in yield in the untreated plots was 11.76 per cent less than in the treated plots. There were 8 generas of nematode in the sugarcane field. The number of nematodes was 3,588 per cent in 500 grams of treated soil and 1,710 nematodes per 500 grams of soil untreated soil Nematodes were Tylenchorhynchus sp. 52.13 per cent and Pratylenchus sp. 17.92 per cent.

It suggested that a reduction of yield of 11.76 per cent between untreated plot and treated plot would have been more or less this due to the nematodes laid out for effectiveness of chlordane in controlling sugarcane stem boring grubs and this was no specific line made for control of the nematodes. This factor should therefore be taken into accounts before any further test will be made on crop losses.

Birchfield (1984) reported that the threshold density of Tylenchorhynchus spp. was 500 per 450 cm³ of soil. The number of nematodes did not correlate to the yield in either the treated or untreated plot. The yield loss of sugarcane U-Thong I was 36.31 per

cent. The yield loss due to sugarcane stem boring grub was greater in U-Thong 1 than in F156 because the nematode infestation in F156 was greater than in U-Thong 1.

Oxamyl at a rate of 18 litre/rai was used to control nematodes in ratoon cane. Yield loss of sugarcane due to nematode was 17.39 per cent in plant cane U-Thong 1 and 23.70 per cent in ratoon cane F156. In plant cane (U-Thong 1 varieties) yield reduced 36.31 per cent and the percentage of infested stalk was 5.09 per cent.

Crop loss assessment in ratoon cane F156 was studied using pairs of untreated cane and treated cane with chlordane 700 millilitre/rai. The results showed that a percentage of infested stalk was 19.40 per cent, a decrease of yield was 50.81 per cent. Prachaubmoh and Pitaksa (1988) reported that infested stools reduction weight of cane about 43 per cent due to sugarcane stem boring grubs.

A comparison of the efficiency of insecticide to control sugarcane stem boring grubs, Dorysthenes buqueti Guerin. The result shows that chlordane at a rate of 700 millilitre/rai was effective but it has a long residual effect in the soil. Endosulfan + BPMC was effective too when applied 3 times per crop, ie. after 3, 4 and 5 months of planting in May, August and September.

Pitfall trap has the potential in controlling the sugarcane stem boring grub. It was found more mass capturing the sugarcane stem boring grub on the ratoon cane than the plant cane field conditions. The adults fall into the traps at night, while they were walking in the cane field in order to mate and lay eggs. However, 80 per cent of females did not lay eggs. The ratio between male and female was 1.3 : 1 (plant cane in Chonburi province) and 2.1 : 1, 1.1 : 1 (ratoon cane in Chonburi and Prachuab Kerikhan province respectively).