Laboratory Evaluation of Insecticides Against Fifth-Instar Spruce Budworm Larvae, Choristoneura fumiferana (Clem.) in 1968

Project No. CC-4

by

P. C. Nigam

Chemical Control Research Institute

Ottawa, Ontario

Information Report CC-X-1

Canadian Forestry Service

Department of Fisheries and Forestry

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Errata

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Table of Contents - Appendix - List of Insecticides (Table 10)
should read (Table 18)

Page 44 - Table 18 - List of Insecticides and Source -
5. Phosphamidon ... Chevron - should read Ciba

CONTENTS

CODES

Mort.	=	Mortality
Corr. Mort.	=	Corrected Mortality
D/T	=	Dead/Total
gpa	=	gallons per acre
SBW	=	Spruce budworm
*	=	Regression is not significant

INTRODUCTION

Spruce budworm (Choristoneura fumiferana Clem) infestation is a perpetual problem in Canadian forests. In 1967 approximately 1.04 million acres were treated for its control. DDT had been used in New Brunswick since 1952, but in recent years there are signs of resistance in spruce budworm to DDT, and also the use of DDT is restricted due to the hazard to wildlife and fish. Phosphamidon and Sumithion have been used in operational control after preliminary laboratory tests in 1965 on spruce budworm larvae collected from New Brunswick (Randall & Nigam, 1966). There is still a need for a better insecticide for its control.

In 1968, seventeen insecticides were tested for contact toxicity against 5th instar Spruce budworm larvae collected from Ontario. This population had no previous history of any insecticidal control. The toxicity data obtained from this population could be used as a reference for comparison with budworm populations had continuous pressure of insecticides.

METHODS AND MATERIALS

(1) Spruce budworm larvae

Third and 4th instar larvae of spruce budworm were collected from Ottawa area during May, 1968. The larvae were reared to 5th instar in growth chambers. The growth chambers were maintained normally at 70°F. and 55 - 60% R.H., although larval development was delayed at times to fit the spray program by lowering the temperature to 40°F. The larvae were reared in plastic trays containing freshly collected spruce or balsam buds. The bottoms of the trays were lined

with paper towelling. Fresh food and clean towelling were provided every other day.

(ii) Insecticides and their formulations

The details of insecticide formulations used in this study are given in Table 18. The concentration of each insecticide used is given in the plan of each experiment. The insecticides were diluted from the concentrates with dyed Velsicol AR50G to the final concentration. DuPont oil red (0.5%) was used as a tracer dye. Data for Cidial, Abate and Zytron are not presented because regression lines could not be obtained.

(iii) Insecticide Treatment

The spraying procedure was very similar to that described by Nigam (1968a and 1969a). A modified Potter tower was calibrated to deliver volumes of dyed insecticide solutions resulting in deposits of 0.1, 0.2, 0.4, 0.6, 0.8 and 1 gallon per acre. The calibration of the tower was carried out in time units (Nigam, 1967); using a micro-syringe for the standard deposit on the required surface area (9 cm No. 1 Whatman filter paper circles). The deposits of insecticide were determined by colorimeter method as described by Rayner (1956). Thirty larvae per dosage in replicate groups of 10 were sprayed to determine contact toxicity. The spray was applied directly onto CO_2 anaesthetized larvae placed on the Whatman filter paper circles. The deposit was calculated in $\mu g/cm^2$ and used for the probit analysis. Two types of controls were used in the preliminary studies, i.e., controls treated with dyed solvents and without solvent treatment. There was no apparent effect of the solvent on the control mortality, so controls without solvent treatment were used in the final studies.

The details of each experiment are described individually (Experiment 1 - 14).

(iv) Observation and analysis of data

The larvae were held at 70°F. and 55 - 60% R.H. after treatment and provided with fresh foliage. Mortality counts were made at 24, 48, and 72 hours after treatment and corrected for control mortality according to Abbott's formula (1925). Probit analysis of the data was carried out according to Finney (1964) using program No. S103 prepared by Statistical Research Service, Canada Department of Agriculture for a Univac 1108 Computer. The Computer Service was provided by Biometric and Computer division of Canada Department of Fisheries & Forestry. The relative potencies of the insecticides were calculated according to Finney (1964) and toxicity index according to Sun (1950) using DDT as the standard insecticide.

EXPERIMENTS AND RESULTS

The plan of each insecticide treatment is presented individually (Experiments 1 - 14), and mortality observed for 24, 48 and 72 hours after treatment are tabulated for each experiment (Table 1 - 14). The results of probit analysis for each period of observation are given at the end of each experiment and regression lines for 24, 48 and 72 hours are drawn for each experiment (Figures 1 - 14). The comparative contact toxicity of the insecticides at 24, 48 and 72 hours after treatment against the larvae is presented in Tables 15 - 17, and Figures 15 - 17. The insecticides are arranged in descending order of toxicity on the basis of LD50 values in these tables and

graphs. In the case of Cidial, Abate and Zytron no regression lines were obtained so data are not included in the present report.

The toxicity at the LD50 level is increased for all the insecticides with increasing period of exposure (i.e. from 24 - 72 hours), with the exception of Baytex. The increase in toxicity due to the exposure period is not significant in some cases while in others it is. At the LD95 level toxicity is increased with time for Zectran, Matacil, Dibrom, Ciba - 9491, Imidan, Anthio, DDT, Baygon & VCS - 506, while for Sumithion it is decreased (Figure 4). However, this decrease is not significant when the fiducial limits are considered and the same is true for some cases where toxicity is increased. Phosphamidon, Baytex and Cygon treatment had no definite response in relation to time. This uneven pattern in toxicity in relation to time within the same insecticide may be due to interferance of insecticides with normal growth during the 72 hours and the effect of control mortality on the population tested. The homogeneity of the population changes gradually with time. The population does not remain the same as it was during the first 24 hour period and may become more heterogenous or homogenous depending upon the response by 72 hours, due to the effect of insecticide on the normal larval development. This may be reflected in the slopes and fiducial limits, e.g., Cygon, Baygon, and DDT etc., (Experiments 11, 13 and 14). Although in the fast acting insecticides, such as Sumithion and Dibrom etc., or at higher concentrates of insecticides, where more than 60% of the population is killed within a 24 hour period further changes due to increase in time are not very significant.

The slopes of these regression lines are not the same within the same insecticide for a different period of observation (Figure 1 - 14). Similarly slopes are also not parallel when different insecticides are compared at the same period of observation (Figures 15 - 17). So the lines are not parallel either in the same insecticide for different period of observation or in different insecticides for the same period of observation, when analysed for single line probit analysis.

The insecticides can be loosely grouped on the basis of their slopes (b values). Sumithion, Phosphamidon and Dibrom have higher b values, i.e., steeper slopes, while DDT, Baytex and Baygon have very low b values, and the lines are very flat. Zectran, Matacil and Cygon have higher b values than DDT, Baytex and Baygon but not as high as Sumithion and Phosphamidon. The other insecticides fall in between the two extremes.

The relative potency and toxicity Index of insecticides are given in Tables 16 - 17 for each period of observation. Zectran is the best as contact insecticide followed by Matacil at the LD50 level, while at the LD95 level this order is reversed. Baygon is the least toxic and DDT is better than Baygon but less toxic to budworm larvae than all other insecticides tested. The toxicity of DDT increases with time at both the LD50 and LD95 levels.

Zectran was found effective against other lepidopterous species, e.g., jack pine budworm and eastern and western hemlock loopers etc. (Nigam, 1969b) although Baygon is not toxic to lepidopterous larvae but it is highly effective against sawflies (Nigam, 1968b), and against

balsam woolly aphid (Nigam 1967 and Nigam and Clark 1969).

Out of the three carbamate insecticides, Zectran and Matacil are very toxic to spruce budworm larvae, while Baygon is not effective. It is therefore unreliable to predict toxicity on the basis of chemical grouping and it is essential that each and every compound be tested to determine its toxicity against the species.

SUMMARY

Zectran and Matacil are the most toxic to the 5th instar spruce budworm larvae of the seventeen insecticides tested for contact toxicity under laboratory conditions. Baygon is the least effective. DDT is better than Baygon but less toxic than other insecticides used in the study.

ACKNOWLEDGMENT

The author is grateful to Dr. J.J. Fettes, Director, Chemical Control Research Institute for encouragement and extending facilities. The technical assistance of Mr. A. Danard, Mr. C. Jackson and Mr. J.R. Trinnell is gratefully acknowledged. Sincere thanks are due to Dr. D.M. Brown and his staff of the Biometric and Computer division of Canada Department of Fisheries and Forestry for providing the computer services. The co-operation of other members of the Department, and various insecticidal firms for the supply of insecticide samples is much appreciated.

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EXPERIMENT NO. 1

Object: To determine the contact toxicity of Zectran against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment: Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control).

Concentration of insecticide: 0.1 per cent

Replications: three

No. of larvae per treatment: thirty

Total No. of larvae utilized: two hundred and ten

Expt. Code: SBW-18 Computer Code: SBW-ZEC (74-76)

Table No. 1

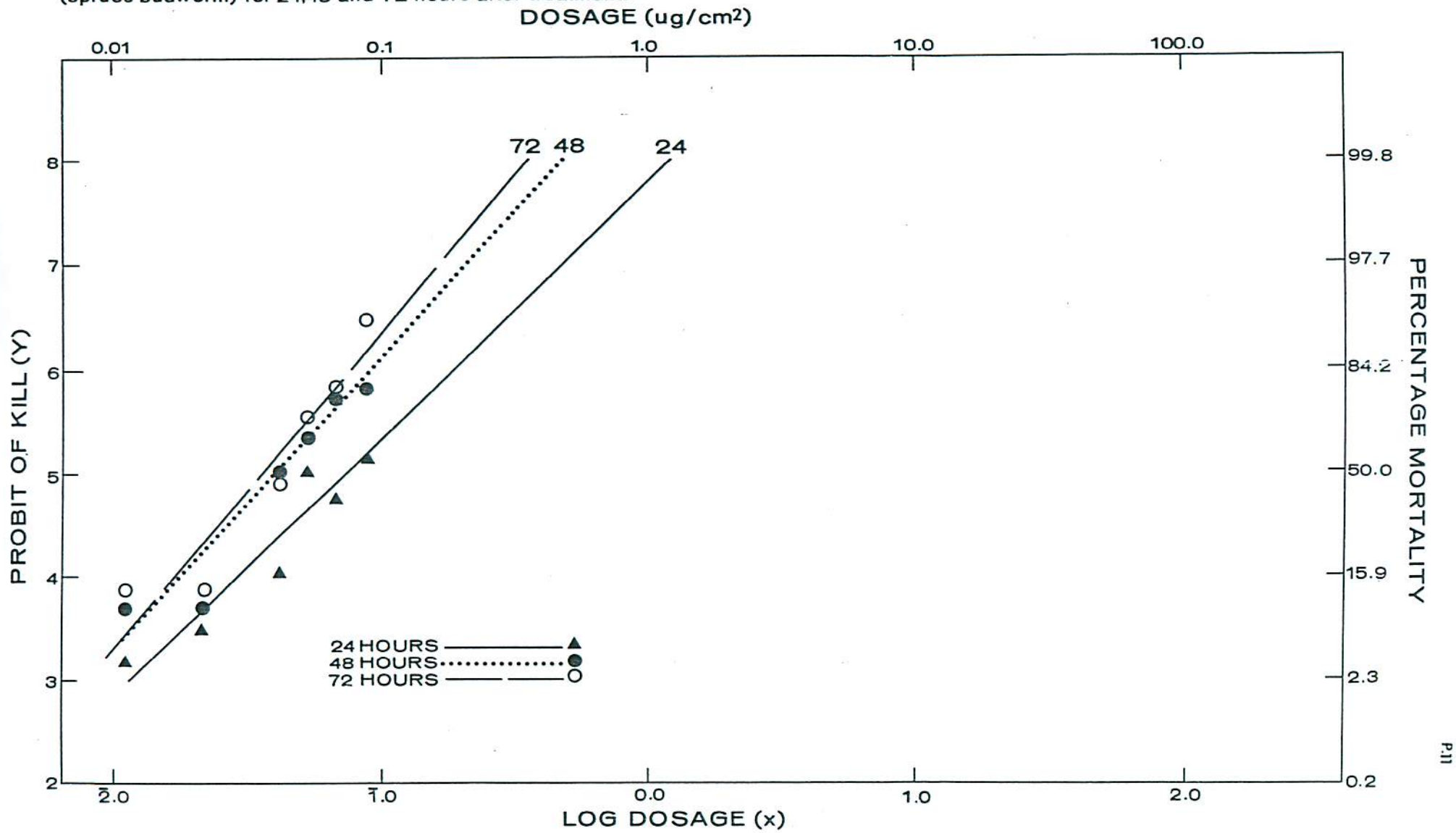
Insecticide		Mortality Counts After								
		24 hours			48 hours			72 hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.0110	1/30	3.33	3.33	3/30	10.00	10.00	4/30	13.33	13.33
0.2	.0210	2/30	6.67	6.67	3/30	10.00	10.00	4/30	13.33	13.33
0.4	.0410	5/30	16.67	16.67	15/30	50.00	50.00	15/30	50.00	50.00
0.6	.0520	15/30	50.00	50.00	19/30	63.33	63.00	21/30	70.00	70.00
0.8	.0660	12/30	40.00	40.00	23/30	76.67	76.67	24/30	80.00	80.00
1.0	.0860	16/29	55.17	55.17	23/29	79.31	79.31	27/29	93.10	93.10
Control		0/29	0.00		0/29	0.00		0/29	0.00	

Findings: The regression lines are given in Fig.1. and the summary of probit analysis is as follows:-

Period	b	LD 50$_2$ ug/cm^2	FL	LD 95$_2$ ug/cm^2	FL
24 hours	2.4625	.7495-01	.6053-01 - .1071	.3490	.1979 - 1.207
48 hours	2.8329	.4123-01	.3447-01 - .4900 -01	.1570	.1132 - .2752
72 hours	3.0434	.3637-01	.3043-01 - .4270 -01	.1263	.9555-01 - .1991

Remarks:

Figure 1. Ld-p lines of Zectran against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24,48 and 72 hours after treatment.



EXPERIMENT NO. 2

Object: To determine the contact toxicity of Matacil against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment: Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, o.8, 1.0 gpa and control)

Concentration of insecticide: 0.1 per cent

Replications: Three

No. of larvae per treatment: Thirty

Total No. of larvae utilized: Two hundred and ten

Expt. Code: SBW-47 Computer Code: SBW-MAT (65-67)

Table No. 2

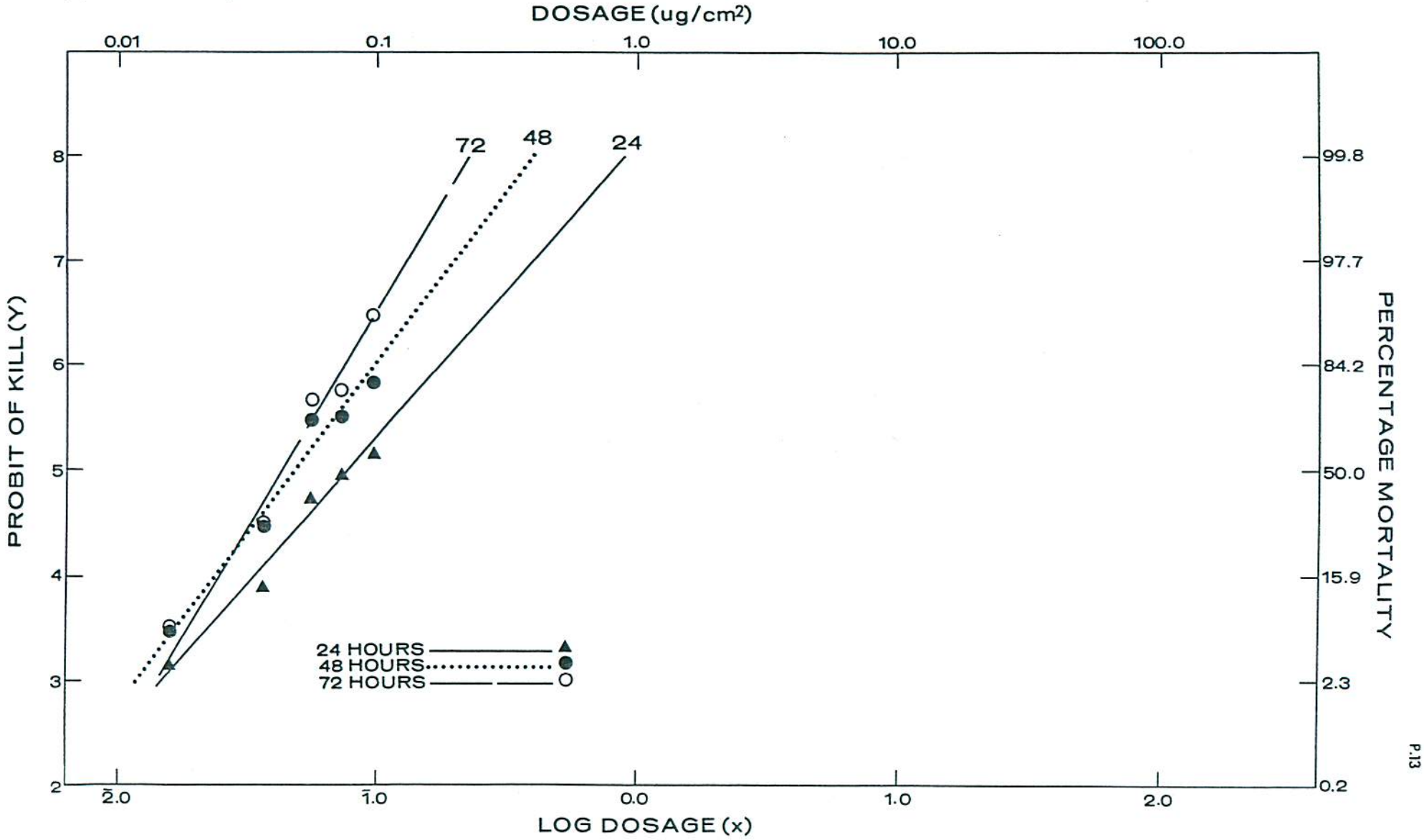
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.0100	0/29	0.00	0.00	0/28	0.00	0.00	0/25	0.00	0.00
0.2	.0160	1/32	3.13	3.13	2/31	6.45	6.45	3/30	10.00	7.00
0.4	.0360	4/30	13.33	13.33	9/30	30.00	30.00	10/30	33.33	31.11
0.6	.0550	11/28	39.29	39.29	19/28	67.86	67.86	21/28	75.00	74.17
0.8	.0720	14/29	48.28	48.28	20/29	68.97	68.97	23/29	79.31	78.62
1.0	.0950	16/29	55.17	55.17	23/29	79.31	79.31	27/29	93.10	92.87
Control		0/31	0.00		0/31	0.00		1/31	3.23	

Findings: The regression lines are given in Fig. 2 and the summary of probit analysis is as follows:-

Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
24 Hours	2.8677	.7802-01	.6443-01 - .1040	.2924	.1842 - .7500
48 Hours	3.3021	.4870-01	.4131-01 - .5739-01	.1534	.1155 - .2449
72 Hours	4.1359	.4316-01	.3564-01 - .4991-01	.1079	.8658-01 - .1600

Remarks:

Figure 2. Ld-p lines of Matacil against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24,48 and 72 hours after treatment.



EXPERIMENT NO. 3

Object: To determine the contact toxicity of Dibrom against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment:	Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control).
Concentration of insecticide:	0.5 per cent
Replications:	Three
No. of larvae per treatment:	Thirty
Total No. of larvae utilized:	Two hundred and ten
Expt. Code: SBW-27	Computer Code: SBW-DIB (43-45)

Table No. 3

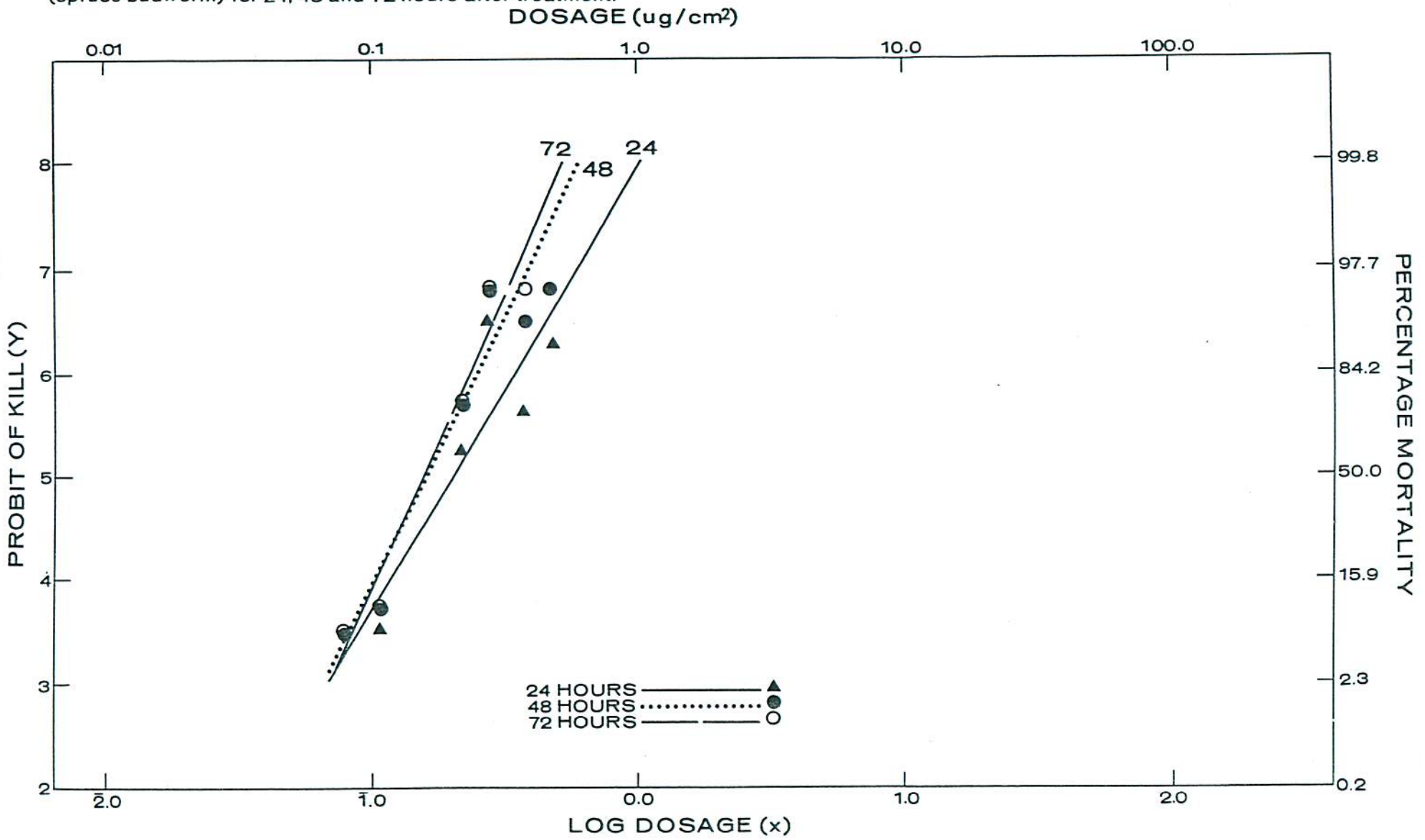
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.0780	0/29	0.00	0.00	2/29	6.90	6.90	2/29	6.90	6.90
0.2	.1070	2/28	7.14	7.14	3/28	10.71	10.71	3/28	10.71	10.71
0.4	.2120	18/30	60.00	60.00	23/30	76.67	76.67	23/30	76.67	76.67
0.6	.2740	28/30	93.33	93.33	29/30	96.67	96.67	29/30	96.67	96.67
0.8	.3700	22/30	73.33	73.33	28/30	93.33	93.33	29/30	96.67	96.67
1.0	.4690	27/30	90.00	90.00	29/30	96.67	96.67	30/30	100.00	100.00
Control		0/28	0.00		0/28	0.00		0/28	0.00	

Findings: The regression lines are given in Fig. 3 and the summary of probit analysis is as follows:-

	Period	b	LD 50$_2$ ug/cm^2	FL	LD 95$_2$ ug/cm^2	FL
*	24 Hours	4.3817	.2047		.4859	
	48 Hours	5.0935	.1615	.1415 - .1820	.3398	.2898 - .4262
	72 Hours	5.8668	.1568	.1385 - .1758	.2992	.2582 - .3686

Remarks:

Figure 3. Ld-p lines of Dibrom against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24, 48 and 72 hours after treatment.



EXPERIMENT NO. 4

Object: To determine the contact toxicity of Sumithion against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment:	Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)
Concentration of insecticide:	One per cent
Replications:	Three
No. of larvae per treatment:	Thirty
Total No. of larvae utilized:	Two hundred and ten
Expt. Code: SBW(PORT)-54	Computer Code: SBP-SUM (131-133)

Table No. 4

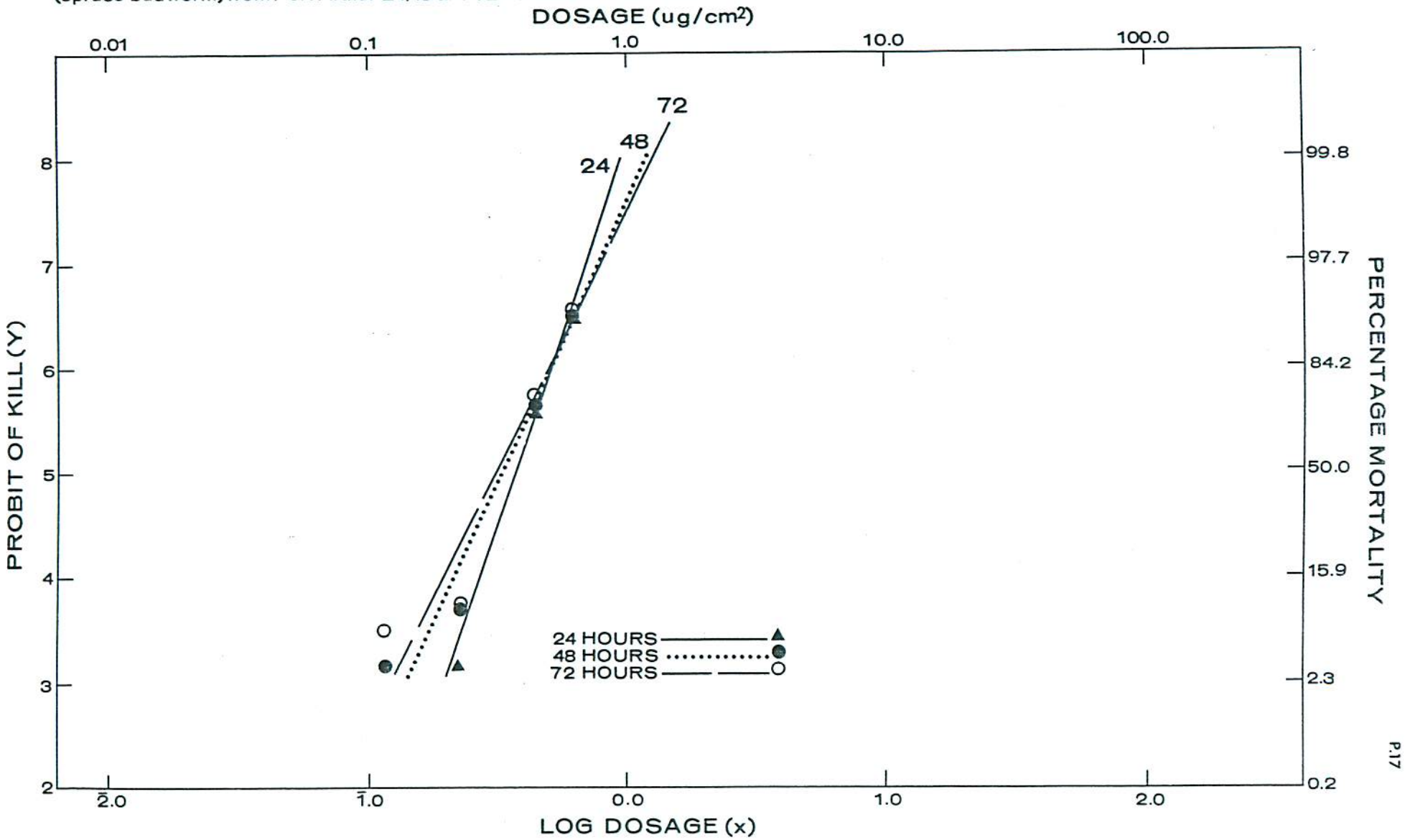
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.1150	0/30	0.00	0.00	1/30	3.33	3.33	2/30	6.67	6.67
0.2	.2240	1/30	3.33	3.33	3/30	10.00	10.00	3/30	10.00	10.00
0.4	.4370	23/31	74.19	74.19	23/31	74.19	74.19	24/31	77.42	77.42
0.6	.6020	28/30	93.33	93.33	28/30	93.33	93.33	28/30	93.33	93.33
0.8	.8580	30/30	100.00	100.00	30/30	100.00	100.00	30/30	100.00	100.00
1.0	1.1360	28/28	100.00	100.00	28/28	100.00	100.00	28/28	100.00	100.00
Control		0/30	0.00		0/30	0.00		0/30	0.00	

Findings: The regression lines are given in Fig. 4 and the summary of probit analysis is as follows:-

Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
24 Hours	7.4535	.3729	.3269 - .4175	.6199	.5331 - .8154
48 Hours	5.5984	.3325	.2885 - .3761	.6542	.5583 - .8287
72 Hours	5.0563	.3147	.2063 - .4249	.6657	.4805 - 1.551

Remarks:

Figure 4. Ld-p lines of Sumithion against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) from Port Arthur 24,48 and 72 hours after treatment.



EXPERIMENT NO. 5

Object: To determine the contact toxicity of Phosphamidon against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment: Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)

Concentration of insecticide: One per cent

Replications: Three

No. of larvae per treatment: Thirty

Total No. of larvae utilized: Two hundred and ten

Expt. Code: SBW(PORT)-51 Computer Code: SBP-PHO (128-130)

Table No. 5

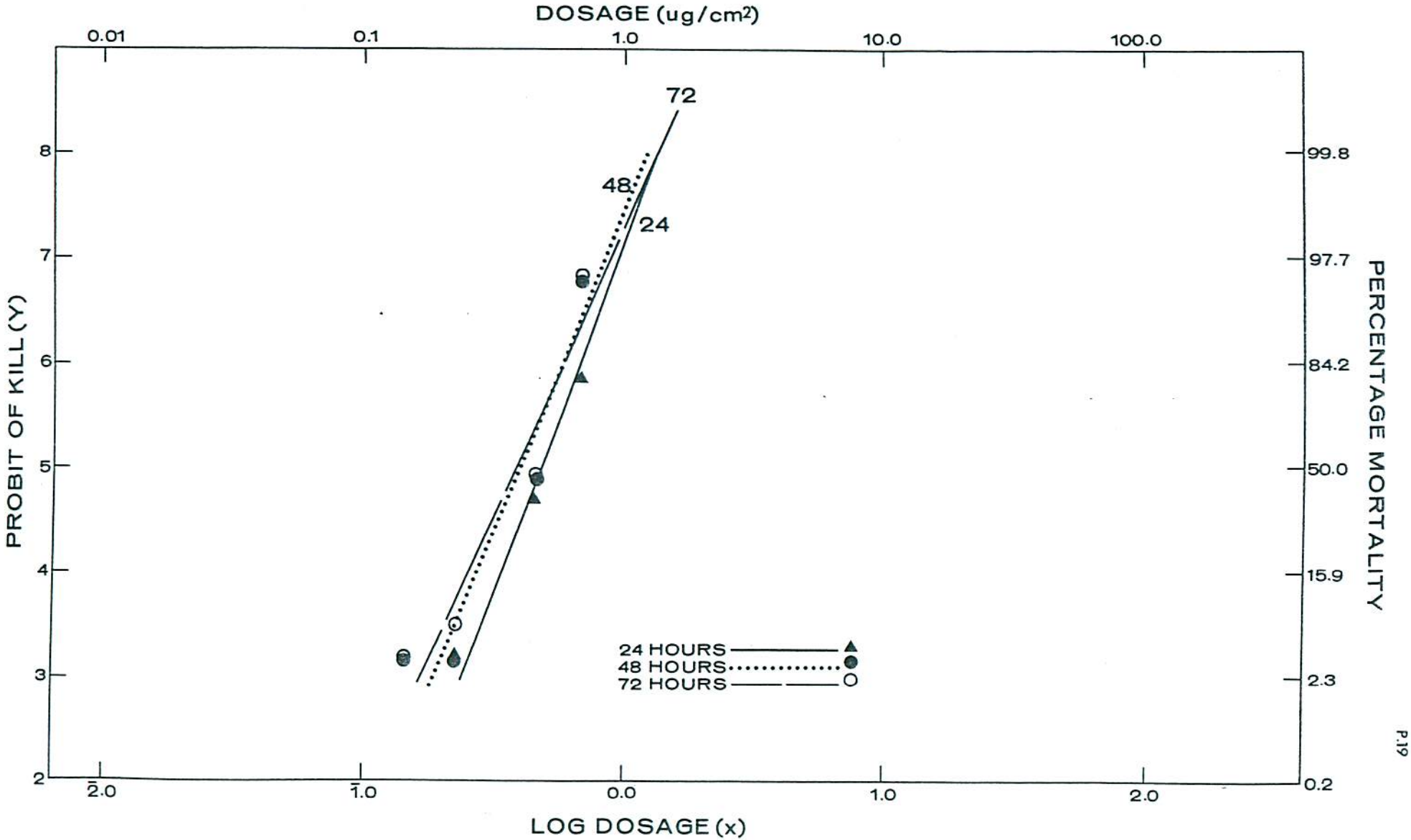
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.1400	0/27	0.00	0.00	1/27	3.70	3.70	1/27	3.70	3.70
0.2	.2240	1/29	3.45	3.45	1/29	3.45	3.45	2/29	6.90	6.90
0.4	.4480	11/29	37.93	37.93	14/29	48.28	48.28	14/29	48.28	48.28
0.6	.6760	24/30	80.00	80.00	29/30	96.67	96.67	29/30	96.67	96.67
0.8	.8730	30/30	100.00	100.00	30/30	100.00	100.00	30/30	100.00	100.00
1.0	1.1510	30/30	100.00	100.00	30/30	100.00	100.00	30/30	100.00	100.00
Control		0/30	0.00		0/30	0.00		0/30	0.00	

Findings: The regression lines are given in Fig. 5 and the summary of probit analysis is as follows:-

Period	b	LD 50$_2$ ug/cm^2	FL	LD 95$_2$ ug/cm^2	FL
24 Hours	6.7629	.4778	.4191 - .5308	.8366	.7325 - 1.030
48 Hours	6.1627	.4025	.1784 - .6065	.7442	.5182 - 4.502
72 Hours	5.8191	.3923	.2551 - .5272	.7523	.5540 - 1.729

Remarks:

Figure 5. Ld-p lines of Phosphamidon against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) from Port Arthur 24, 48 and 72 hours after treatment.



EXPERIMENT NO. 6

Object: To determine the contact toxicity of Cyan 47031 against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment:	Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)
Concentration of insecticide:	Three per cent
Replications:	Three
No. of larvae per treatment:	Thirty
Total No. of larvae utilized:	Two hundred and ten
Expt. Code: SBW-41.	Computer Code: SBW-CYN(71-73).

Table No. 6

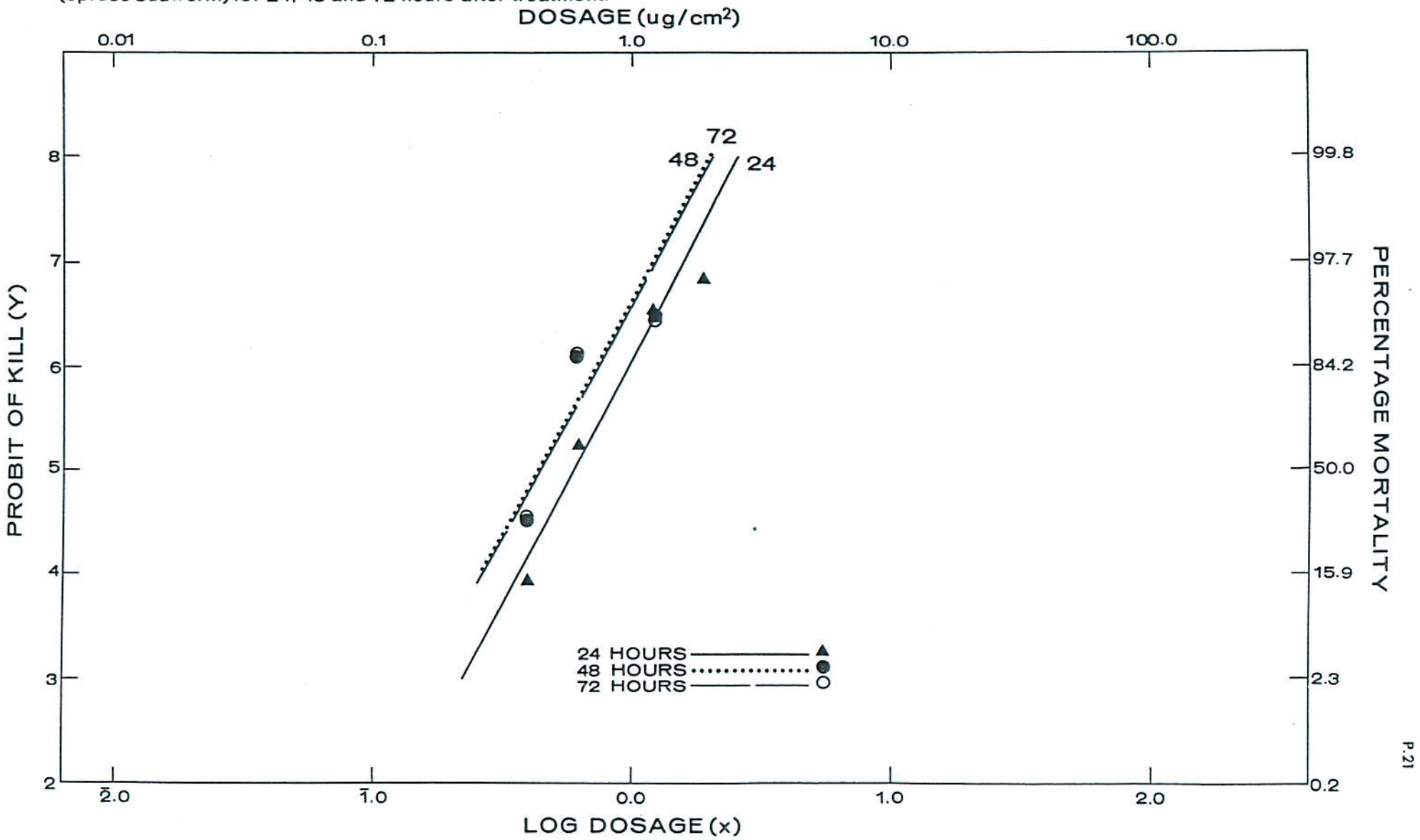
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.3920	4/29	13.79	13.79	9/29	31.03	31.03	9/29	31.03	31.03
0.2	.6010	17/29	58.62	58.62	25/29	86.21	86.21	25/29	86.21	86.21
0.4	1.2020	28/30	93.33	93.33	28/30	93.33	93.33	28/30	93.33	93.33
0.6	1.8610	29/30	96.67	96.67	30/30	100.00	100.00	30/30	100.00	100.00
0.8	2.4590	30/30	100.00	100.00	30/30	100.00	100.00	30/30	100.00	100.00
1.0	3.3070	30/30	100.00	100.00	30/30	100.00	100.00	30/30	100.00	100.00
Control		0/30	0.00		0/28	0.00		0/28	0.00	

Findings: The regression lines are given in Fig. 6 and the summary of probit analysis is as follows:-

Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
24 Hours	4.6758	.5982	.5086 - .6922	1.345	1.092 - 1.895
48 Hours	4.5538	.4467	.3532 - .5236	1.026	.8190 - 1.630
72 Hours	4.5538	.4467	.3532 - .5236	1.026	.8190 - 1.630

Remarks:

Figure 6. Ld-p lines of Cyanamid 47031 against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24, 48 and 72 hours after treatment.



EXPERIMENT NO. 7

Object: To determine the contact toxicity of Ciba 9491 against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment:	Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)
Concentration of insecticide:	Two per cent
Replications:	Three
No. of larvae per treatment:	Thirty
Total No. of larvae utilized:	Two hundred and ten
Expt. Code: SBW-49	Computer Code: SBW-C94 (68-70)

Table No. 7

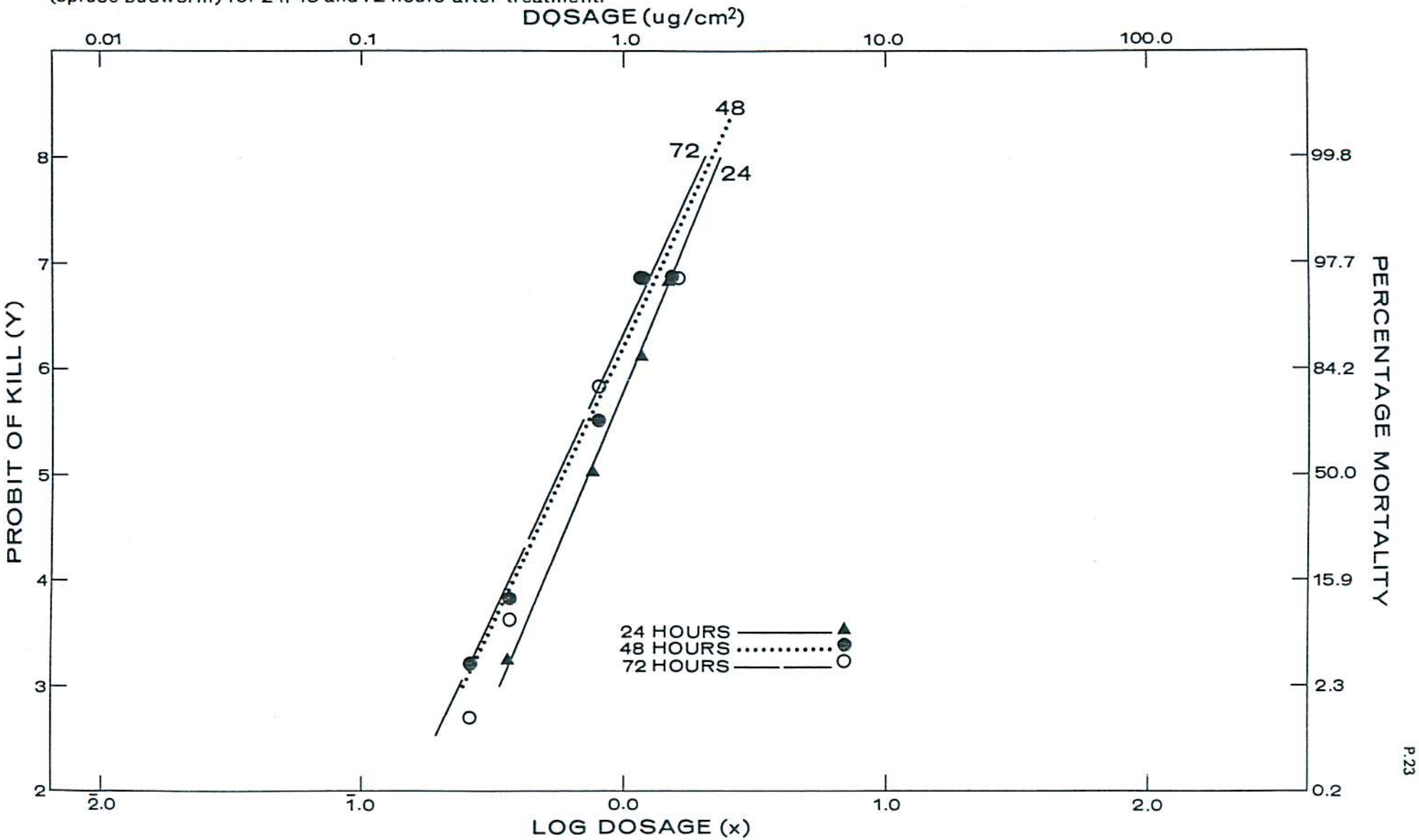
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.2590	0/28	0.00	0.00	1/27	3.70	3.70	1/27	3.70	0.14
0.2	.3520	1/25	4.00	4.00	3/25	12.00	12.00	3/25	12.00	8.74
0.4	.7530	15/30	50.00	50.00	21/30	70.00	70.00	24/30	80.00	79.26
0.6	1.1630	26/30	86.67	86.67	29/30	96.67	96.67	29/30	96.67	96.54
0.8	1.5040	29/30	96.67	96.67	29/30	96.67	96.67	29/30	96.67	96.54
1.0	1.9450	30/30	100.00	100.00	30/30	100.00	100.00	30/30	100.00	100.00
Control		0/28	0.00		0/28	0.00		1/28	3.57	

Findings: The regression lines are given in Fig. 7 and the summary of probit analysis is as follows:-

Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
24 Hours	5.9583	.7438	.6447 - .8368	1.405	1.215 - 1.745
48 Hours	5.2104	.5855	.5061 - .6684	1.211	1.024 - 1.539
72 Hours	5.7259	.5816	.4880 - .6696	1.127	.9554 - 1.447

Remarks:

Figure 7. Ld-p lines of Ciba-9491 against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24, 48 and 72 hours after treatment.



EXPERIMENT NO. 8

Object: To determine the contact toxicity of VCS 506 against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment:	Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)
Concentration of insecticide:	One per cent
Replications:	Three
No. of larvae per treatment:	Thirty
Total No. of larvae utilized:	Two hundred and ten
Expt. Code: SBW-32	Computer Code SBW-VC6 (53-55)

Table No. 8

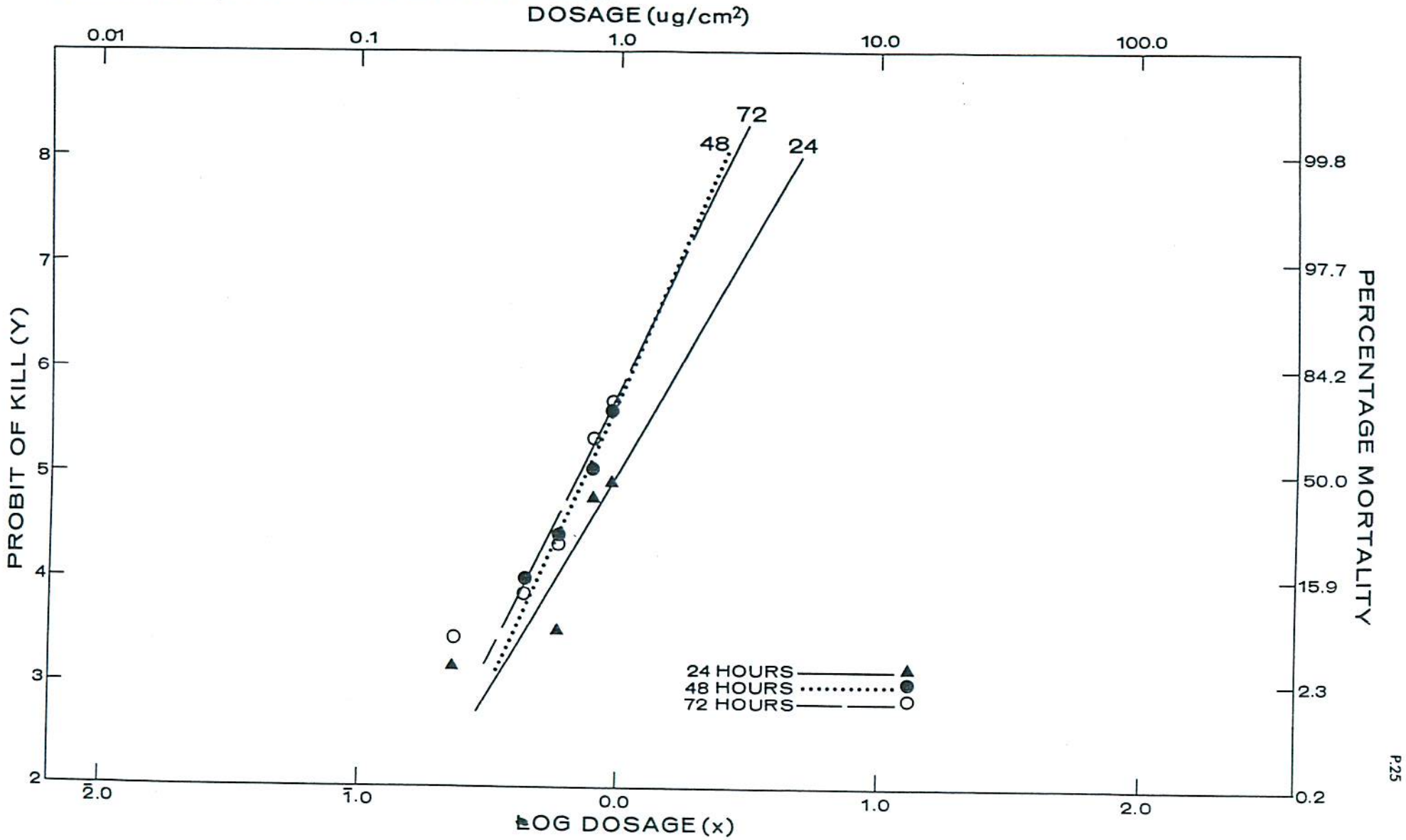
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.1280	0/30	0.00	0.00	0/30	0.00	0.00	0/30	0.00	0.00
0.2	.2270	1/31	3.23	3.23	1/31	3.23	0.00	4/31	12.90	6.68
0.4	.4240	0/29	0.00	0.00	5/27	18.52	15.71	5/27	18.52	12.70
0.6	.5820	2/30	6.67	6.67	9/30	30.00	27.59	9/30	30.00	25.00
0.8	.7870	12/30	40.00	40.00	16/30	53.33	51.72	20/30	66.67	64.29
1.0	.9280	14/30	46.67	46.67	22/30	73.33	72.41	23/30	76.67	75.00
Control		0/30	0.00		1/30	3.33		2/30	6.67	

Findings: The regression lines are given in Fig. 8 and the summary of probit analysis is as follows:-

Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
24 Hours	4.3701	1.002	.8527 - 1.431	2.385	1.593 - 7.094
48 Hours	5.5674	.7372	.6585 - .8374	1.456	1.162 - 2.395
72 Hours	5.2433	.7026	.6201 - .8130	1.447	1.102 - 3.282

Remarks:

Figure 8. Ld-p lines of VCS-506 against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24, 48 and 72 hours after treatment.



EXPERIMENT NO. 9

Object: To determine the contact toxicity of Imidan against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment:	Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)
Concentration of insecticide:	Two per cent
Replications:	Three
No. of larvae per treatment:	Thirty
Total No. of larvae utilized:	Two hundred and ten
Expt. Code: SBW-26	Computer Code: SBW-1M1 (40-42)

Table No. 9

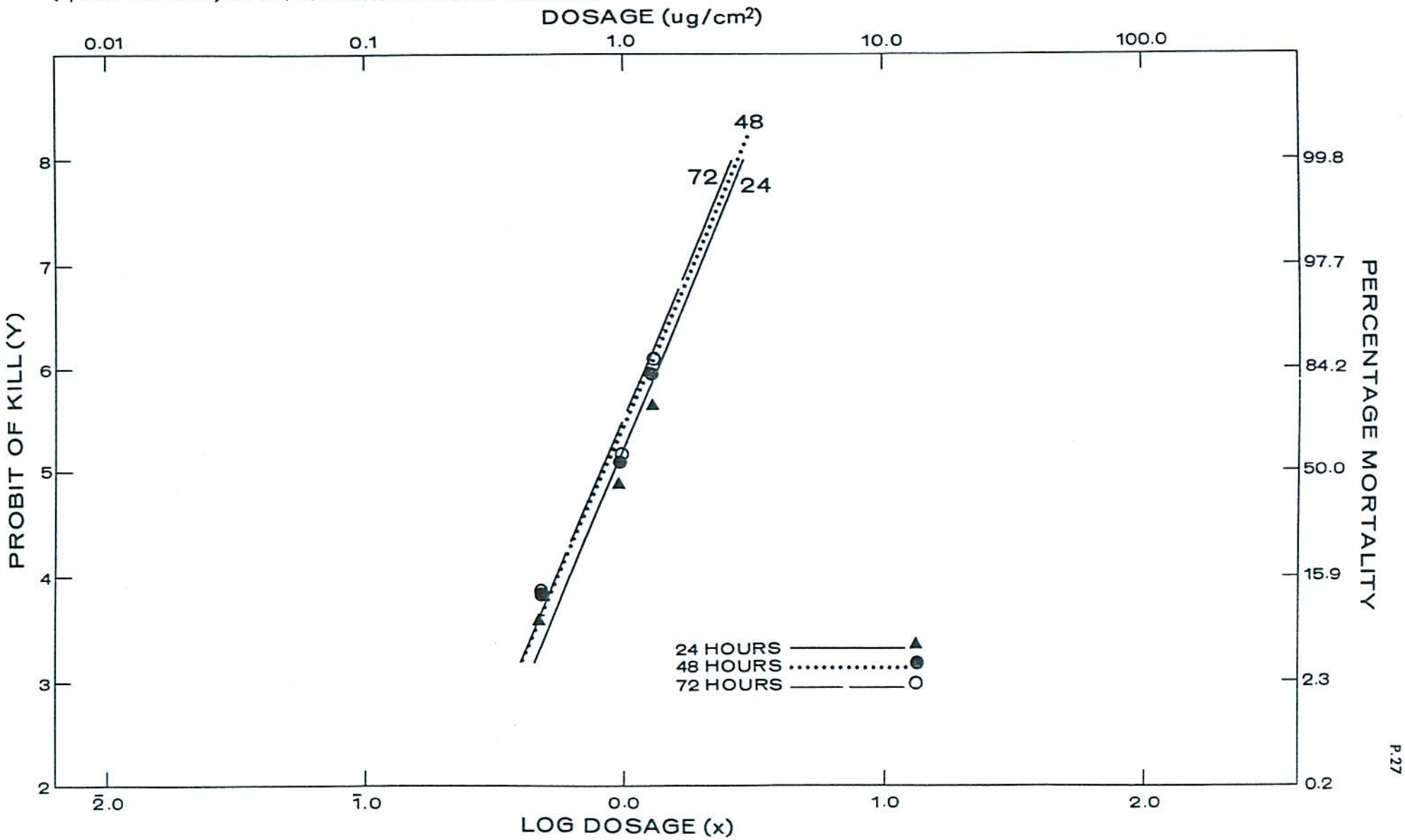
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.2470	0/30	0.00	0.00	0/30	0.00	3.45	1/30	0.00	0.00
0.2	.4610	2/26	7.69	7.69	4/26	15.38	12.47	4/26	15.38	12.47
0.4	.9360	13/29	44.83	44.83	16/29	55.17	53.63	17/29	58.62	57.19
0.6	1.2590	22/30	73.33	73.33	25/30	83.33	82.76	26/30	86.67	86.21
0.8	1.6750	30/30	100.00	100.00	30/30	100.00	100.00	30/30	100.00	100.00
1.0	2.4910	30/30	100.00	100.00	30/30	100.00	100.00	30/30	100.00	100.00
Control		0/30	0.00		1/30	3.33		1/30	3.33	

Findings: The regression lines are given in Fig. 9 and the summary of probit analysis is as follows:-

Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
24 Hours	5.9881	.9181	.7984 - 1.026	1.728	1.493 - 2.184
48 Hours	5.8381	.8343	.6966 - .9466	1.596	1.371 - 2.062
72 Hours	5.8765	.8059	.6726 - .9158	1.536	1.320 - 1.972

Remarks:

Figure 9. Ld-p lines of Imidan against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24, 48 and72 hours after treatment.



EXPERIMENT NO. 10

Object: To determine the contact toxicity of Baytex against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment:	Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)
Concentration of insecticide:	Two per cent
Replications:	Three
No. of larvae per treatment:	Thirty
Total No. of larvae utilized:	Two hundred and ten
Expt. Code: SBW-39	Computer Code: SBW-BEX (59-61)

Table No. 10

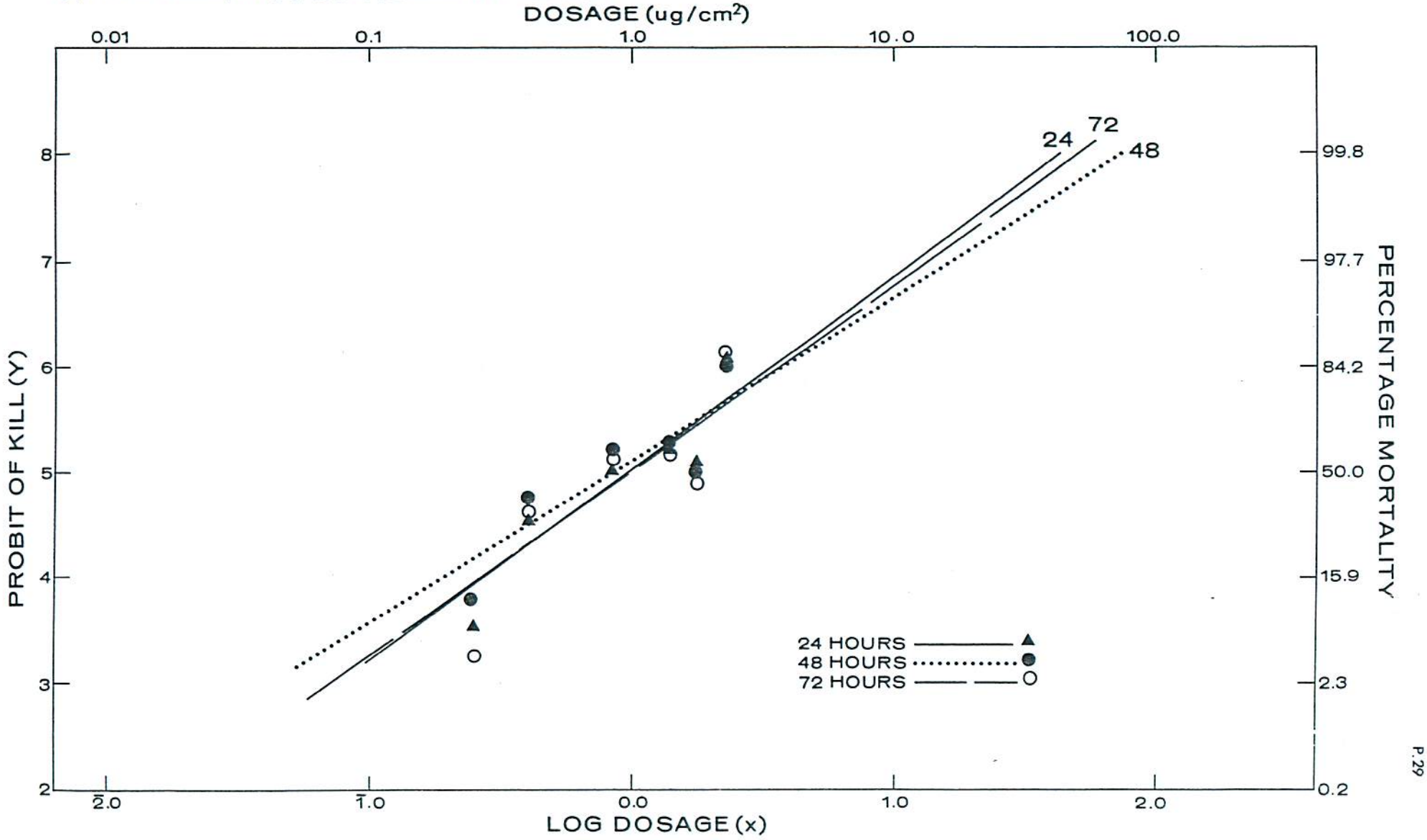
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.2440	3/29	10.34	7.14	5/28	17.86	11.54	5/28	17.86	4.17
0.2	.4000	10/29	34.48	32.14	12/27	44.44	40.17	12/27	44.44	35.19
0.4	.8180	15/29	51.72	50.00	18/29	62.07	59.15	18/29	62.07	55.75
0.6	1.3570	18/30	60.00	58.57	19/30	63.33	60.51	19/30	63.33	57.22
0.8	1.7530	15/28	53.57	51.91	15/28	53.57	50.00	15/28	53.57	45.83
1.0	2.2660	24/28	85.71	85.20	24/28	85.71	84.62	25/28	89.29	87.50
Control		1/29	3.45		2/28	7.14		4/28	14.29	

Findings: The regression lines are given in Fig. 10 and the summary of probit analysis is as follows:-

	Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
	24 Hours	1.8195	.9746	.7343 - 1.297	7.817	4.281 - 26.93
	48 Hours	1.5134	.8440	.5687 - 1.186	10.32	4.749 - 68.97
*	72 Hours	1.7333	.9672		8.603	

Remarks:

Figure 10. Ld-p lines of Baytex against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24, 48 and 72 hours after treatment.



EXPERIMENT NO. 11

Object: To determine the contact toxicity of Cygon against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment:	Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)
Concentration of insecticide:	Two per cent
Replications:	Three
No. of larvae per treatment:	Thirty
Total No. of larvae utilized:	Two hundred and ten
Expt. Code: SBW-28	Computer Code: SBW-CYG (46-48)

Table No. 11

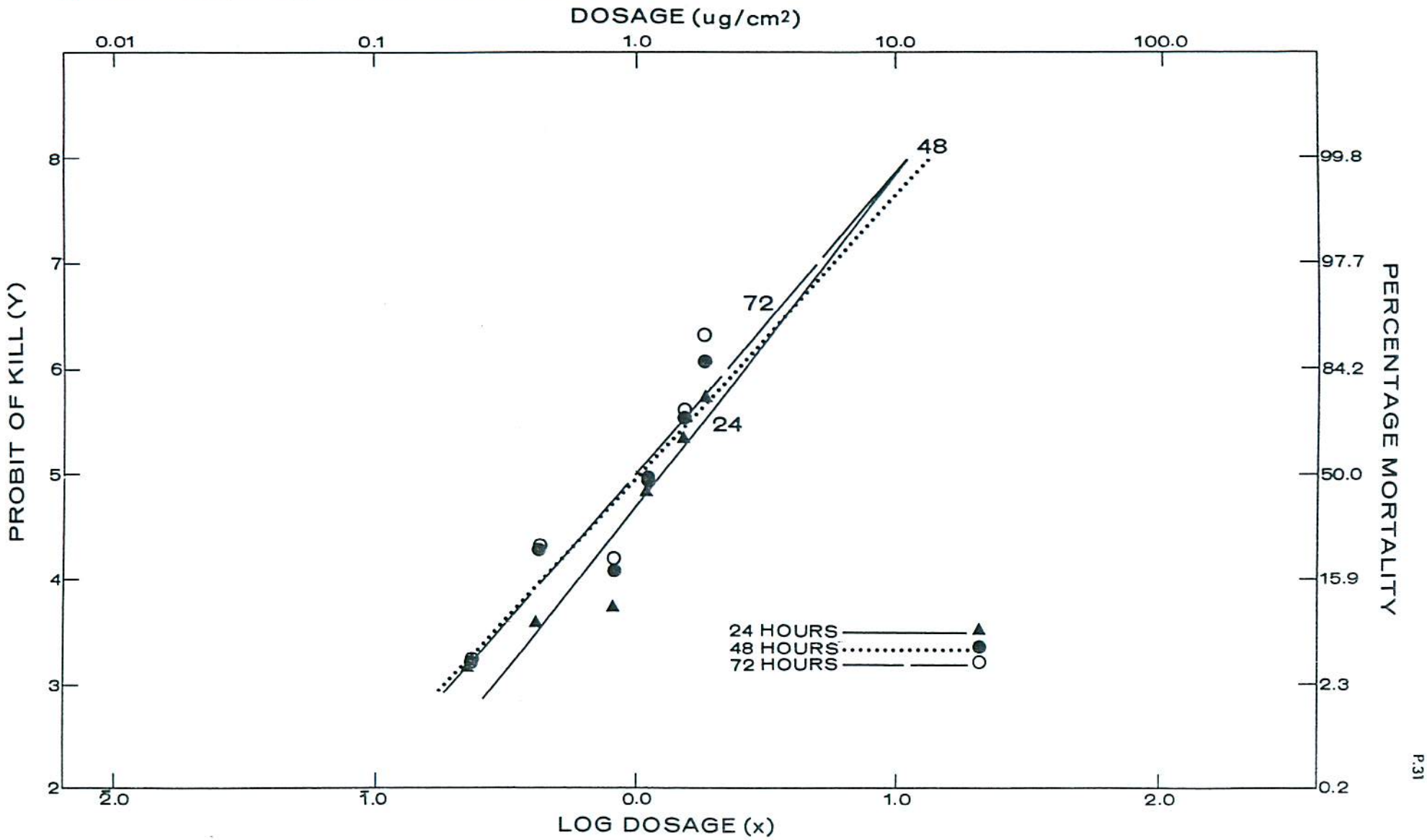
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.2240	1/29	3.45	3.45	1/29	3.45	3.45	1/27	3.70	3.70
0.2	.4050	2/25	8.00	8.00	6/25	24.00	24.00	6/24	25.00	25.00
0.4	.8100	3/28	10.71	10.71	5/28	17.86	17.86	6/28	21.43	21.43
0.6	1.0990	13/30	43.33	43.33	14/30	46.67	46.67	14/30	46.67	46.67
0.8	1.4910	19/30	63.33	63.33	21/30	70.00	70.00	22/30	73.33	73.33
1.0	1.7920	16/21	76.19	76.19	18/21	85.71	85.71	19/21	90.48	90.48
Control		0/30	0.00		0/30	0.00		0/30	0.00	

Findings: The regression lines are given in Fig. 11 and the summary of probit analysis is as follows:-

Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
24 Hours	3.1593	1.255	1.063 - 1.550	4.163	2.852 - 8.775
48 Hours	2.7386	1.053	.4554 - 5.759	4.199	1.883 -.2391 + 07
72 Hours	2.8466	.9926	.3390 - 4.517	3.756	1.753 -.8360 + 07

Remarks:

Figure 11. Ld-p lines of Cygon against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24, 48 and 72 hours after treatment.



EXPERIMENT NO. 12

Object: To determine the contact toxicity of Anthio against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment: Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)

Concentration of insecticides: Two per cent

Replications: Three

No. of larvae per treatment: Thirty

Total No. of larvae utilized: Two hundred and ten

Expt. Code: SBW-38 Computer Code: SBW-ANT (56-58)

Table No. 12

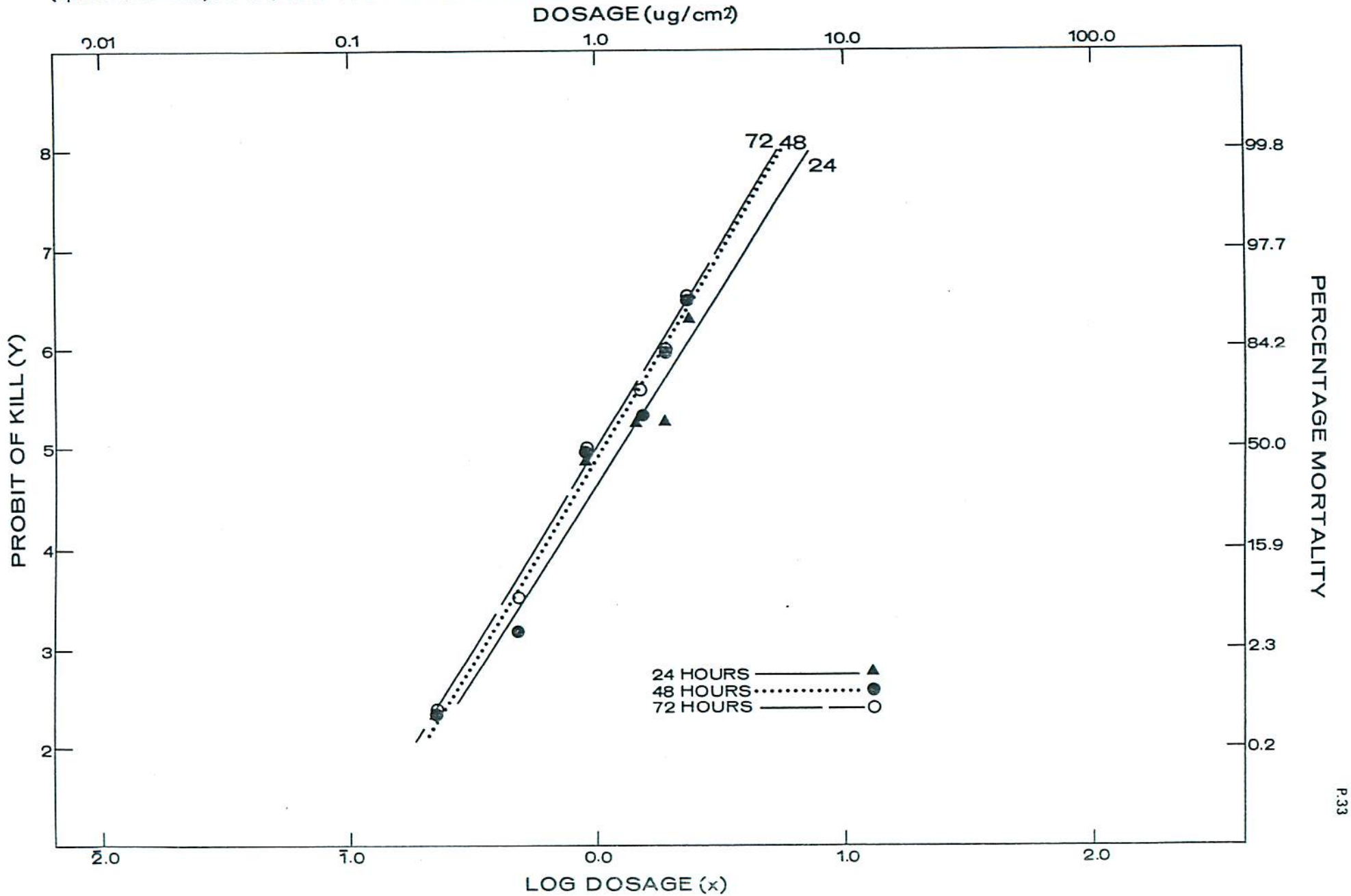
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.2240	0/27	0.00	0.00	1/27	3.70	0.38	1/27	3.70	0.38
0.2	.4730	0/30	0.00	0.00	2/30	6.67	3.45	3/30	10.00	6.90
0.4	.9150	13/29	44.83	44.83	14/28	50.00	48.28	14/28	50.00	48.28
0.6	1.4210	18/30	60.00	60.00	19/30	63.33	62.07	22/30	73.33	72.41
0.8	1.8490	18/30	60.00	60.00	25/30	83.33	82.76	25/30	83.33	82.76
1.0	2.3130	27/30	90.00	90.00	28/30	93.33	93.10	28/30	93.33	93.10
Control		0/30	0.00		1/30	3.33		1/30	3.33	

Findings: The regression lines are given in Fig. 12 and the summary of probit analysis is as follows:-

Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
24 Hours	3.9033	1.253	1.081 - 1.439	3.307	2.613 - 4.907
48 Hours	4.1631	1.079	.9010 - 1.243	2.681	2.171 - 3.859
72 Hours	4.0137	1.010	.8374 - 1.169	2.596	2.096 - 3.722

Remarks:

Figure 12. Ld-p lines of Anthio against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24, 48 and 72 hours after treatment.



EXPERIMENT NO. 13

Object: To determine the contact toxicity of DDT against V instar Spruce Budworm larvae.

Plan of Experiment:

Treatment: Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)

Concentration of insecticides: Five per cent

Replications: Three

No. of larvae per treatment: Thirty

Total No. of larvae utilized: Two hundred and ten

Expt. Code: SBW-43 Computer Code: SBW-DDT (151-153)

Table No. 13

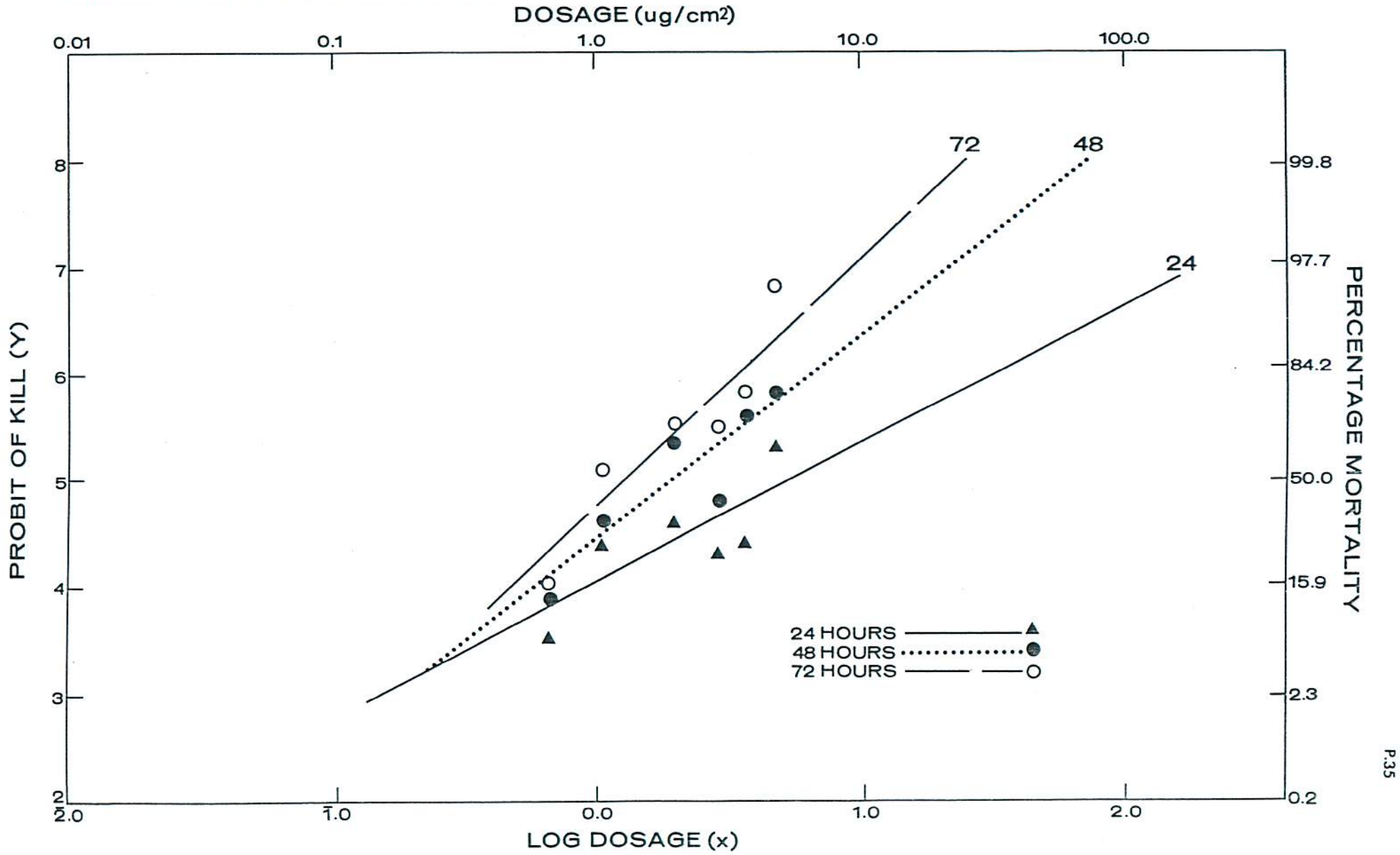
Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.6540	2/30	6.67	6.67	4/30	13.33	13.33	5/30	16.67	16.67
0.2	1.0560	8/30	26.67	26.67	10/29	34.48	34.48	15/28	53.57	53.57
0.4	1.9660	10/30	33.33	33.33	19/30	63.33	63.33	21/30	70.00	70.00
0.6	2.8590	7/29	24.14	24.14	12/29	41.38	41.38	20/29	68.97	68.97
0.8	3.6550	8/30	26.67	26.67	21/29	72.41	72.41	23/29	79.31	79.31
1.0	4.6550	18/29	62.07	62.07	23/29	79.31	79.31	28/29	96.55	96.55
Control		0/30	0.00		0/30	0.00		0/30	0.00	

Findings: The regression lines are given in Fig. 13 and the summary of probit analysis is as follows:-

Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
24 Hours	1.3039	5.502	3.571 - 18.06	100.5	25.54 - 9922.0
48 Hours	1.9125	1.992	1.538 - 2.553	14.43	8.310 - 44.43
72 Hours	2.3443	1.320	1.002 - 1.625	6.641	4.666 - 12.34

Remarks:

Figure13. Ld-p lines of DDT against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24,48 and 72 hours after treatment.



EXPERIMENT NO. 14

Object: To determine the contact toxicity of Baygon against V instar Spruce Budworm larvae.

Plan of experiment:

Treatment: Seven (six rates of application - 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 gpa and control)

Concentration of insecticide: Four per cent

Replications: Three

No. of larvae per treatment: Thirty

Total No. of larvae utilized: Two hundred and ten

Expt. Code: SBW (PORT)-55 Computer Code: SBP-BAY (134,157 & 135)

Table No. 14

Insecticide		Mortality Counts After								
		24 Hours			48 Hours			72 Hours		
gpa	Dosage ug/cm^2	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.	D/T	% Mort.	Corr. Mort.
0.1	.5160	0/30	0.00	0.00	0/30	0.00	3.70	0/30	0.00	3.70
0.2	.9390	2/29	6.90	6.90	2/29	6.90	3.45	2/29	6.90	3.45
0.4	1.6590	7/30	23.33	23.33	12/30	40.00	37.78	12/30	40.00	37.78
0.6	2.6900	8/30	26.67	26.67	9/30	30.00	27.41	14/30	46.67	44.69
0.8	3.4320	7/30	23.33	23.33	16/30	53.33	51.60	19/30	63.33	61.98
1.0	4.4990	7/30	23.33	23.33	10/30	33.33	30.86	13/30	43.33	41.23
Control		0/28	0.00		1/28	3.57		1/28	3.57	

Findings: The regression lines are given in Fig. 14 and the summary of probit analysis is as follows:-

	Period	b	LD 50 ug/cm^2	FL	LD 95 ug/cm^2	FL
	24 Hours	1.3625	10.37	5.491 - 97.13	167.2	33.21 - .8133+05
*	48 Hours	1.8612	4.876		37.33	
*	72 Hours	2.2846	3.435		18.03	

Remarks:

Figure 14. Ld-p lines of Baygon against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) from Port Arthur 24, 48 and 72 hours after treatment.

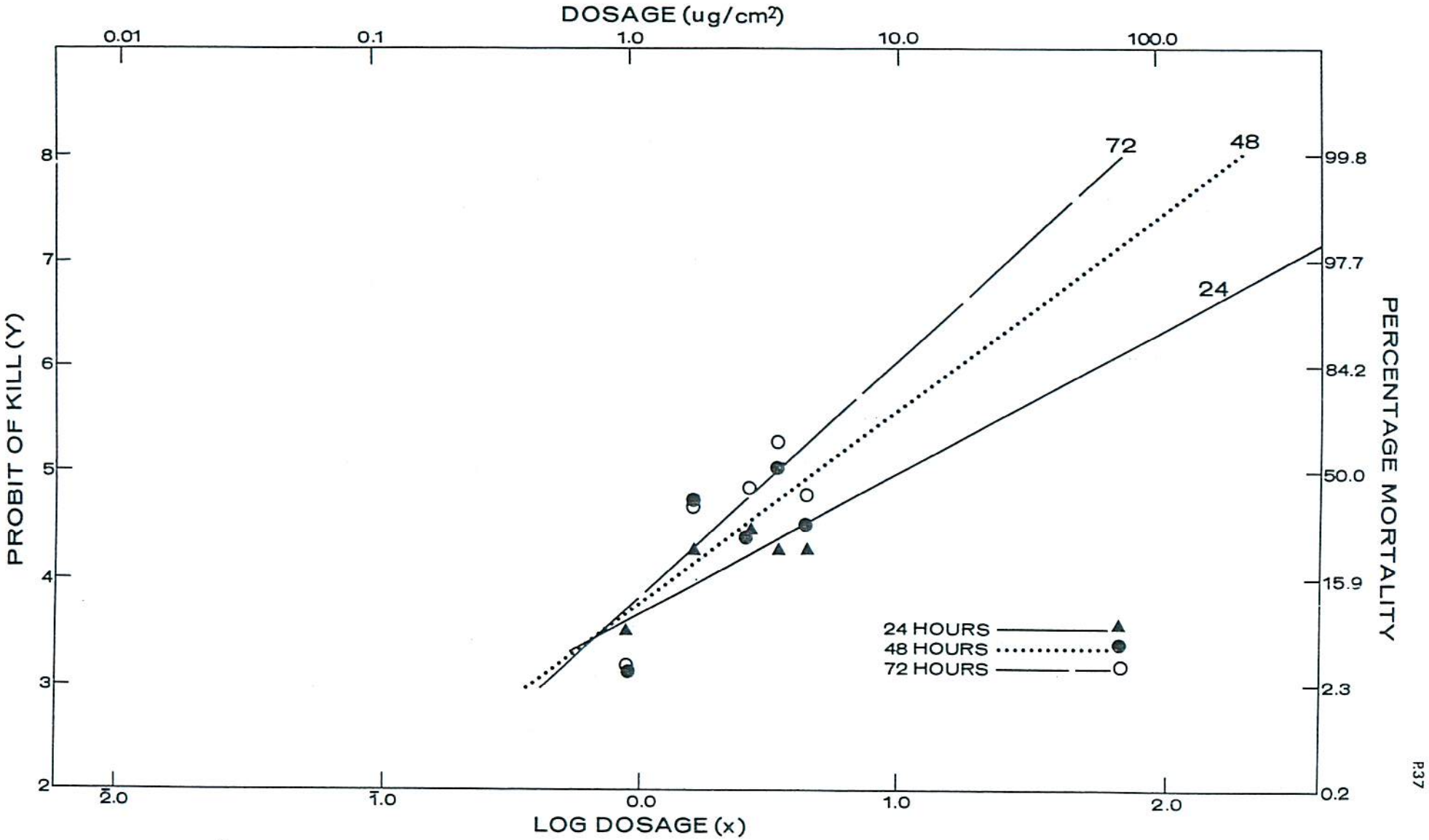


TABLE NO. 15

Toxicity of Insecticides to Spruce Budworm larvae
24 hours after treatment

Insecticide	LD 50 ug/cm^2	Fiducial Limits	Relative Potency	Toxicity Index	LD 95 ug/cm^2	Fiducial Limits	Relative Potency
Zectran®	0.075	0.061 -0.107	73.4	7340	0.349	0.198 - 1.207	288.0
Matacil®	0.078	0.064 - 0.104	70.5	7050	0.292	0.184 - 0.750	344.2
Dibrom®	0.205		26.8	2680	0.486		206.8
Sumithion®	0.373	0.327 - 0.417	14.7	1470	0.620	0.533 -0.815	162.1
Phosphamidon	0.478	0.419 - 0.531	11.5	1150	0.837	0.732 - 1.030	120.1
Cyan 47031	0.598	0.509 - 0.692	9.2	920	1.345	1.092 - 1.895	74.7
Ciba 9491	0.744	0.645 - 0.837	7.4	740	1.405	1.215 - 1.745	71.5
Imidan®	0.918	0.798 - 1.026	6.0	600	1.728	1.493 - 2.184	58.2
Baytex®	0.975	0.734 - 1.297	5.6	560	7.817	4.281 - 26.930	12.9
VCS 506®	1.002	0.853 - 1.431	5.5	550	2.385	1.593 - 7.094	42.1
Anthio®	1.253	1.081 - 1.439	4.4	440	3.307	2.613 - 4.907	30.4
Cygon®	1.255	1.063 - 1.550	4.4	440	4.163	2.852 - 8.775	24.1
DDT	5.502	3.571 - 18.060	1.0	100	100.500	25.540 - 9922.000	1.0
Baygon®	10.370	5.491 - 97.130	0.5	50	167.200	33.210 - 81330.000	0.6

Figure 15. Comparative Ld-p lines of insecticides against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 24 hours after treatment.

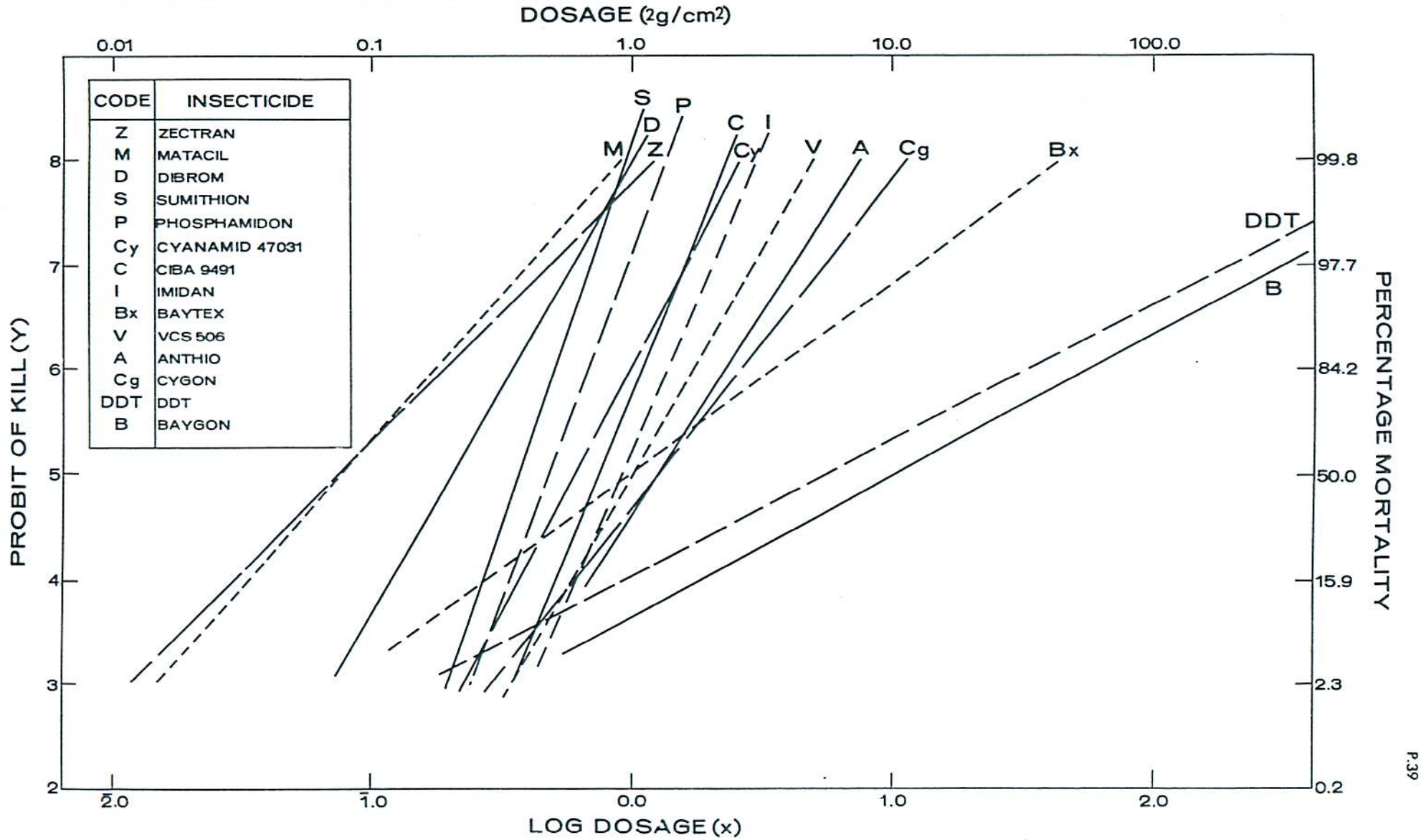


TABLE NO. 16

Toxicity of Insecticides to Spruce Budworm larvae
48 hours after treatment

Insecticide	LD 50 ug/cm^2	Fiducial Limits	Relative Potency	Toxicity Index	LD 95 ug/cm^2	Fiducial Limits	Relative Potency
Zectran®	0.041	0.034 -0.049	48.6	4860	0.157	0.113 -0.275	91.9
Matacil®	0.049	0.041 - 0.057	40.7	4070	0.153	0.116 - 0.245	94.3
Dibrom®	0.161	0.141 - 0.182	12.4	1240	0.340	0.290 - 0.426	42.4
Sumithion®	0.332	0.288 -0.376	6.0	600	0.654	0.558 -0.829	22.1
Phosphamidon	0.402	0.178 - 0.606	5.0	500	0.744	0.518 - 4.502	19.4
Cyan 47031	0.447	0.353 -0.524	4.5	450	1.026	0.819 - 1.630	14.1
Ciba 9491	0.585	0.506 - 0.668	3.4	340	1.211	1.024 - 1.539	11.9
VCS 506®	0.737	0.658 - 0.837	2.7	270	1.456	1.162 - 2.395	9.9
Imidan®	0.834	0.697 - 0.947	2.4	240	1.596	1.371 - 2.062	9.0
Baytex®	0.844	0.569 - 1.186	2.4	240	10.320	4.749 - 68.970	1.4
Cygon®	1.053	0.455 - 5.759	1.9	190	4.199	1.883 - 2391000.0	3.4
Anthio®	1.079	0.901 - 1.243	1.8	180	2.681	2.171 - 3.859	5.4
DDT	1.992	1.538 - 2.553	1.0	100	14.430	8.310 - 44.430	1.0
Baygon®	4.876		0.4	41	37.330		0.4

Figure 16. Comparative Ld-p lines of insecticides against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 48 hours after treatment.

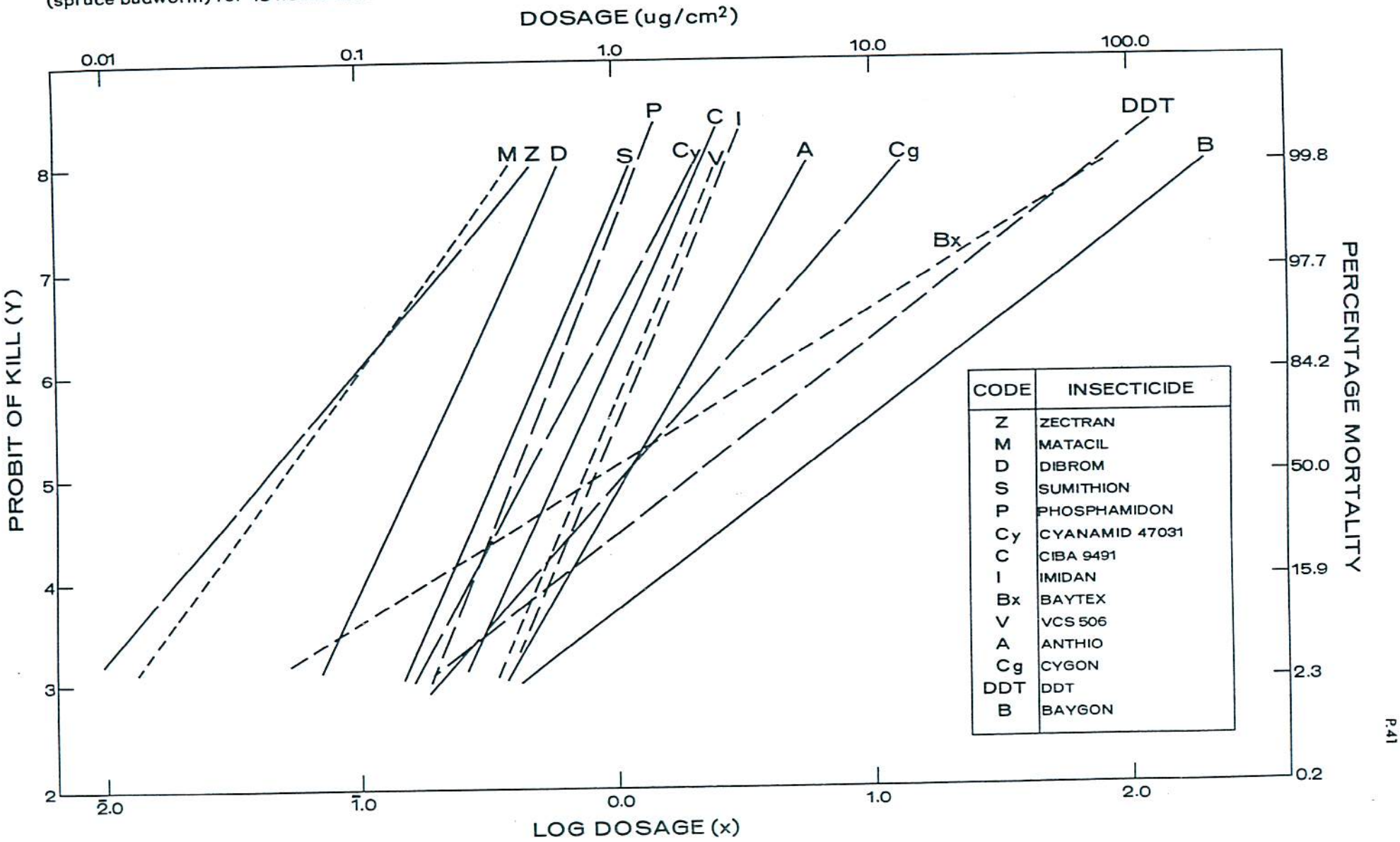


TABLE NO. 17

Toxicity of Insecticides to Spruce Budworm larvae
72 hours after treatment

Insecticide	LD 50 ug/cm^2	Fiducial Limits	Relative Potency	Toxicity Index	LD 95 ug/cm^2	Fiducial Limits	Relative Potency
Zectran®	0.036	0.030 - 0.043	36.7	3670	0.126	0.096 - 0.199	52.7
Matacil®	0.043	0.036 - 0.050	30.7	3070	0.108	0.087 - 0.160	61.5
Dibrom®	0.157	0.138 - 0.176	8.4	840	0.299	0.258 - 0.369	22.2
Sumithion®	0.315	0.206 - 0.425	4.2	420	0.666	0.480 - 1.551	10.0
Phosphamidon	0.392	0.255 - 0.527	3.4	340	0.752	0.554 - 1.729	8.8
Cyan 47031	0.447	0.353 - 0.524	3.0	300	1.026	0.819 - 1.630	6.5
Ciba 9491	0.582	0.488 -0.670	2.3	230	1.127	0.955 - 1.447	5.9
VCS 506®	0.703	0.620 - 0.813	1.9	190	1.447	1.102 - 3.282	4.6
Imidan®	0.806	0.673 - 0.916	1.6	160	1.536	1.320 - 1.972	4.3
Baytex®	0.967		1.4	140	8.603		0.8
Cygon®	0.993	0.339 - 4.517	1.3	130	3.756	1.753 - .8360 + 07	1.8
Anthio®	1.010	0.837 - 1.169	1.3	130	2.596	2.096 - 3.722	2.6
DDT	1.320	1.002 - 1.625	1.0	100	6.641	4.666 - 12.340	1.0
Baygon®	3.435		0.4	38	18.030		0.4

Figure 17. Comparative Ld-p lines of insecticides against fifth instar CHORISTONEURA FUMIFERANA CLEM. (spruce budworm) for 72 hours after treatment.

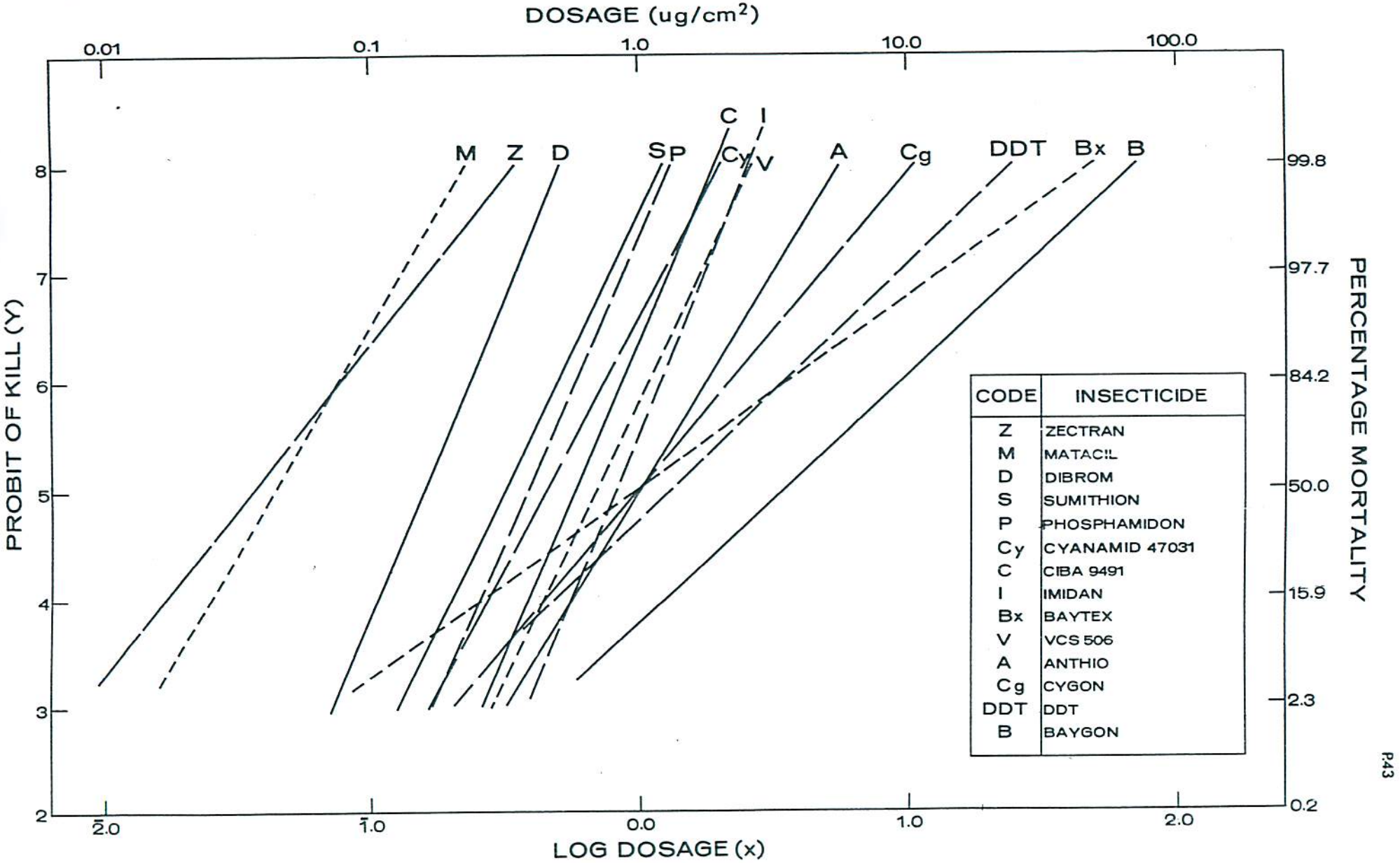


Table 18

List of Insecticides and Source

#	Name	Type	Formula	Source
1	Zectran® (22% E.C.)	carbamate systemic	4-dimethylamino-3, 5-xylyl methylcarbamate	Dow
2	MATACIL® (8% E.C.)	carbamate contact	4-dimethylamino-m-tolyl methylcarbamate	Chemagro
3	DIBROM® (91.9% E.C.)	organo-phos. contact	1,2-dibromo-2,2-dichloroethyl dimethyl phosphate	Chevron
4	Sumithion® (50% E.C.)	organo-phos. systemic	O,O-dimethyl O-(4-nitro-m-tolyl) phosphorothioate	Chemagro
5	Phosphamidon (90% W.M.)	organo-phos. systemic	dimethyl phosphate, ester with 2-chloro-N,N-diethyl-3-hydroxycro=tonamide	Chevron
6	Cyan 47031 (50% E.C.)	organo-phos. contact	P,P-dicthyl cyclic ethylene ester of phosphonodithioimido-carbonic acid	Amer.Cyan.
7	Ciba 9491 (30% E.C.)	organo-phos. contact	O,O-dimethyl-O-2,5-dichloro-4-iodophenyl thiophosphate	CIBA Ltd.
8	VCS 506® (30% E.C.)	organo-phos. contact	not available	Velsicol
9	Imidan® (12% E.C.)	organo-phos. contact	O,O-dimethyl S-phthalimidomethyl phosphorodithioate	Stauffer
10	BAYTEX® (46% E.C.)	organo-phos. contact	O,O-dimethyl O-[4-(Methylthio) -m-tolyl] phosphorothioate	Chemagro
11	Cygon® (40% E.C.)	organo-phos. systemic	O,O-dimethyl S-(methylcarbamoyl= methyl) phosphorodithioate	Amer. Cyan.
12	ANTHIO® (25% E.C.)	organo-phos. systemic	S-((formylmethylcarbamoyl) = methyl) O,O-dimethyl phosphorodithioate	Sandoz
13	DDT (Technical)	chlor.hydro-carbon, contact	1,1,1-trichloro-2,2-bis(p-chloro=phenyl) ethane	Math. Col. & Bell
14	Cidial® (50% E.C.)	organo-phos. contact	ethyl mercaptophenylacetate, O,O-dimethyl phosphorodithioate	F.F.B.
15	Baygon® (13.9% E.C.)	carbamate systemic	o-isopropoxyphenyl methyl = carbamate	Chemagro

#	Name	Type	Formula	Source
16	ABATE® (43% E.C.)	organo-phos. contact	0,0,0',0'-tetramethyl 0,0'-thiodi-p-phenylene phosphorothioate	Amer. Cyan.
17	Zytron® (37.5% E.C)	organo-phos. systemic	0-2,4-dichlorophenyl O-methyl isopropylphosphoramidothioate	Dow

E.C. = emulsifiable concentrate

W.M. = water miscible