CHANGES IN THE BIOMASS OF SPRUCE BUDWORM POPULATIONS DUE TO THE TREATMENTS OF B.t.

File Report No. 5

Aubrey Moore

October, 1980

Forest Pest Management Institute
Canadian Forestry Service
Sault Ste. Marie, Ontario

Introduction

Laboratory studies have shown that B.t. suppresses the feeding activity of surviving spruce budworm larvae (Fig. 6). B.t. can therefore be considered as a combined insecticide/feeding suppressant. One may then ask "What are the relative contributions of these two properties towards foliage protection?" This report describes an initial attempt at answering this question. Due to the *ad hoc* nature of the work, it should be viewed only as precursor to a properly planned study.

In the past we have tried to assess the feeding rates of spruce budworm populations by weighing frass collected on drop sheets. This method is unsatisfactory for the following reasons:

1) One cannot easily estimate the size of the population producing the frass. This would require extensive sampling at different heights in the space above the drop sheet.
2) One cannot account for loss of frass due to the wind or scavengers. (Ants have been observed carrying off quantities of frass).
3) One does not know what proportion of the frass is spruce budworm frass.

During this summer's field program at Riviere-du-Loup, Que., an alternate method of assessing budworm feeding rates was tried, namely the weighing of live larvae collected from branch samples.

Methods

All live insects picked off branches sampled for the purpose of determining population density were killed by dropping them in coffee creamer containers half filled with 75% ethanol. A separate container was used for each tree sampled and the paper cap of each was labelled with the tree identification, number of larvae and/or pupae, and the date of collection. These insect samples were pre-dried in the field laboratory by decanting the ethanol and placing the creamers under an infra-red heat lamp. After two or three hours of drying, the caps were replaced. After my return to FPMI, the insect samples were further dried by removing the caps from the containers and placing them in a vacuum oven set at 30°C for at least 12 hours. The samples were then weighed to the nearest milligram on an electronic balance. Insect samples were collected from 5 plots which were treated as follows:

CP - Untreated
P1 - Thuricide 16B 8 BIU/1 gpa
P2 - Thuricide 24B 8 BIU/1/2 gpa
P3 - Dipel 88 Carrier (no B.t.) 1 gpa
P4 - Dipel 88 8 BIU/1 gpa
P111 - Fenitrothion 2 x 3 oz. A.I./acre

Results

A. Effects of treatments on the weights of individual larvae

The mean dry weights of budworm larvae and pupae are reported, for several dates in June, in tables 1 and 2, and figures, 1, 2 and 3. The following trends in budworm mass are apparent from these data:

1) Budworm feeding on white spruce are heavier than those feeding on balsam fir. In 21 out of 24 pairs of samples taken on the same dates, insects collected on white spruce were heavier than those collected on balsam fir. In the prespray samples, budworm feeding on white spruce were 45% heavier than those feeding on balsam fir.

2) Growth of budworm larvae is retarded by B.t. treatments

This effect is more dramatic on balsam fir than on white spruce (Fig. 1, 2, 3). In the case of P3, the plot treated with Dipel 88 Carrier, a slight reduction in average weight is indicated. By comparison, in Block III, the plot treated with fenitrothion, there is no indication of a decrease in the average mass of the survivors when compared to those in the check plot. There is some indication that survivors may recover by about 2 weeks post-treatment, after which a normal rate of weight increase resumes.

The observed reduction of mean budworm dry weight on white spruce in the check plot, from 19 mg to 13 mg between June 26 and June 30 is unexplained. This coincides with an unusually large reduction in population density (71%) during the 7 days between the first and second post-spray sample. One must conclude that the larger insects were removed from the sampled population.

B. Effects of treatments on budworm biomass

For the purpose of this report budworm biomass will be defined as the dry weight of the total spruce budworm population in terms of milligrams per bud. In other words, this is the mean weight of the insects multiplied by the population density.

Figures 4 and 5 show the changes in budworm biomass on white spruce and balsam fir. In the plots treated with B.t. there is a dramatic decrease in the budworm biomass when compared to the check plot. There is only a small difference between biomass in the check plot and P-3, sprayed with Dipel 88 Carrier.

Population densities were unavailable for the fenitrothion block and, therefore budworm biomass could not be calculated. The following table gives the population density and budworm biomass averaged over the period between the pre-spray sample and the post-spray sample.

PLOT	POPULATION DENSITY (LARVAE PER 1,000 BUDS)	BUDWORM BIOMASS (μg/BUD)	% DEFOLIATION
White Spruce			
Check	180	1241	59
P1 - B.t.	173	379	22
P2 - B.t.	103	371	25
P3 - Carrier	161	966	51
P4 - B.t.	130	304	31
Balsam Fir			
Check	140	918	65
P1 - B.t.	60	54	20
P2 - B.t.	28	71	22
P3 - Carrier	139	743	66
P4 - B.t.	46	261	21

On white spruce there is a much better correlation between biomass and defoliation ($r = 0.97$) than between population density and defoliation ($r = 0.55$). On balsam fir, there is a high correlation in both cases ($r = 0.97$ for each).

Note that, in all cases, there is a greater difference between the biomass in the check plot and that in the treated plot than can be accounted for by the difference in population density. For example, in the case of white spruce in plot 1, there is a 69% difference in biomass, yet only a 4% difference in population density. Therefore, only 4% out of the 69% can be accounted for by reduction in population density. The remaining 65% must be due to sublethal effects (i.e. reduction in the average weight of survivors). This deduction is based upon the premise that, if there are no sublethal effects, the reduction in biomass will equal the reduction in population density. The following table shows the relative contributions of lethal and sublethal effects towards the observed reduction in budworm biomass. Note that when data from all the B.t. plots are pooled, there is a net reduction of 78% in budworm biomass, of which 46% is due to lethal effects and 32% is due to sublethal effects.

PLOT	MEAN BUDWORM BIOMASS		% DIFFERENCE IN BIOMASS		
	TREATED	UNTREATED	TOTAL	DUE TO LETHAL EFFECTS	DUE TO SUBLETHAL EFFECTS
White Spruce					
P1 - B.t.	379	1241	69	4	65
P2 - B.t.	371	1241	70	43	27
P3 - Carrier	966	1241	22	11	11
P4 - B.t.	304	1241	76	28	48
Balsam Fir					
P1 - B.t.	54	918	94	57	37
P2 - B.t.	71	918	92	80	12
P3 - Carrier	743	918	19	0	19
P4 - B.t.	261	918	72	67	4
Both Species					
All B.t. Plots	240	1080	78	46	32
Carrier	854	1080	21	6	15

DISCUSSION

One may state that the aim of any spruce budworm control program is to reduce the conversion of spruce/fir foliage biomass into budworm biomass. B.t. treatments achieve this aim in two ways: by reducing the budworm population density, and by effecting the growth (and presumably the rate of consumption) of survivors. The data suggest that in the past summer's field trials, the sublethal effects provided about 40% of the total reduction in budworm biomass. This implies that measurements of population density alone provide an incomplete assessment of the effects of B.t. on a budworm population. Measurement of budworm biomass involves no increase in sampling and only a small increase in sample processing time in return for a more comprehensive assessment of the total effect of treatments on budworm populations. This improvement in efficacy assessment produces a higher degree of correlation with the impact of populations on the foliage, i.e., defoliation. Budworm biomass measurements would be useful in studying the effect of any control method which has a large sublethal component such as slow-acting insecticides, insect growth regulators, and low-potency pathogens.

Acknowledgments

I would like to thank Dr. O.N. Morris for his encouragement and support. Insect samples from the fenitrothion plot, Block III, were provided by Michel Auger and Paul Brulé of the Quebec Department of Lands and Forests. Their cooperation with us in this past summer's field program was much appreciated.

Table 1 - Average dry weight (in mg) of budworm collected on <u>white spruce</u>. Values in parentheses are average dry weight per bud.

	CP	P1	P2	P3	P4
June 1		0.40			
2		0.24 (0.04)	0.27 (0.04)		
3					0.32
4		0.49			0.38 (0.10)
5	0.51				
6					
7				0.69 (0.15)	
8	1.03 (0.25)	0.82			
9					
10	1.69	0.96			
11					
12					
13					
14					
15					
16					
17					
18					
19		1.96 (0.40)			
20			3.79 (0.30)		6.71 (0.44)
21					
22				9.57 (1.48)	
23	11.83 (2.10)				
24					
25					
26	18.57	11.89 (1.12)	12.89 (1.65)		
27					8.58 (0.34)
28					
29					
30	12.88 (0.67)	14.91		13.00 (1.02)	

Table 2 - Average dry weight (in mg) of budworm collected on <u>balsam fir</u>. Values in parentheses are average dry weight per bud.

	CP		P1		P2		P3		P4		P111
June 1			0.14								
2			0.16	(0.01)	0.23	(0.01)					
3									0.26		
4	0.22		0.46						0.23	(0.02)	
5											
6											
7							0.42	(0.05)			
8	0.80	(0.08)	0.48								
9											
10	1.32		0.31								
11											0.43
12											
13											
14											3.51
15											
16											
17											
18											4.09
19			0.76	(0.04)					1.17	(0.44)	
20					3.92	(0.06)					
21											
22							3.89	(0.56)			3.07
23	6.00	(1.01)									
24											
25											15.99
26	13.89		5.05	(0.21)	4.98	(0.29)					
27									6.42	(0.21)	
28											
29											
30	17.14	(2.42)	12.50				14.97	(2.57)			

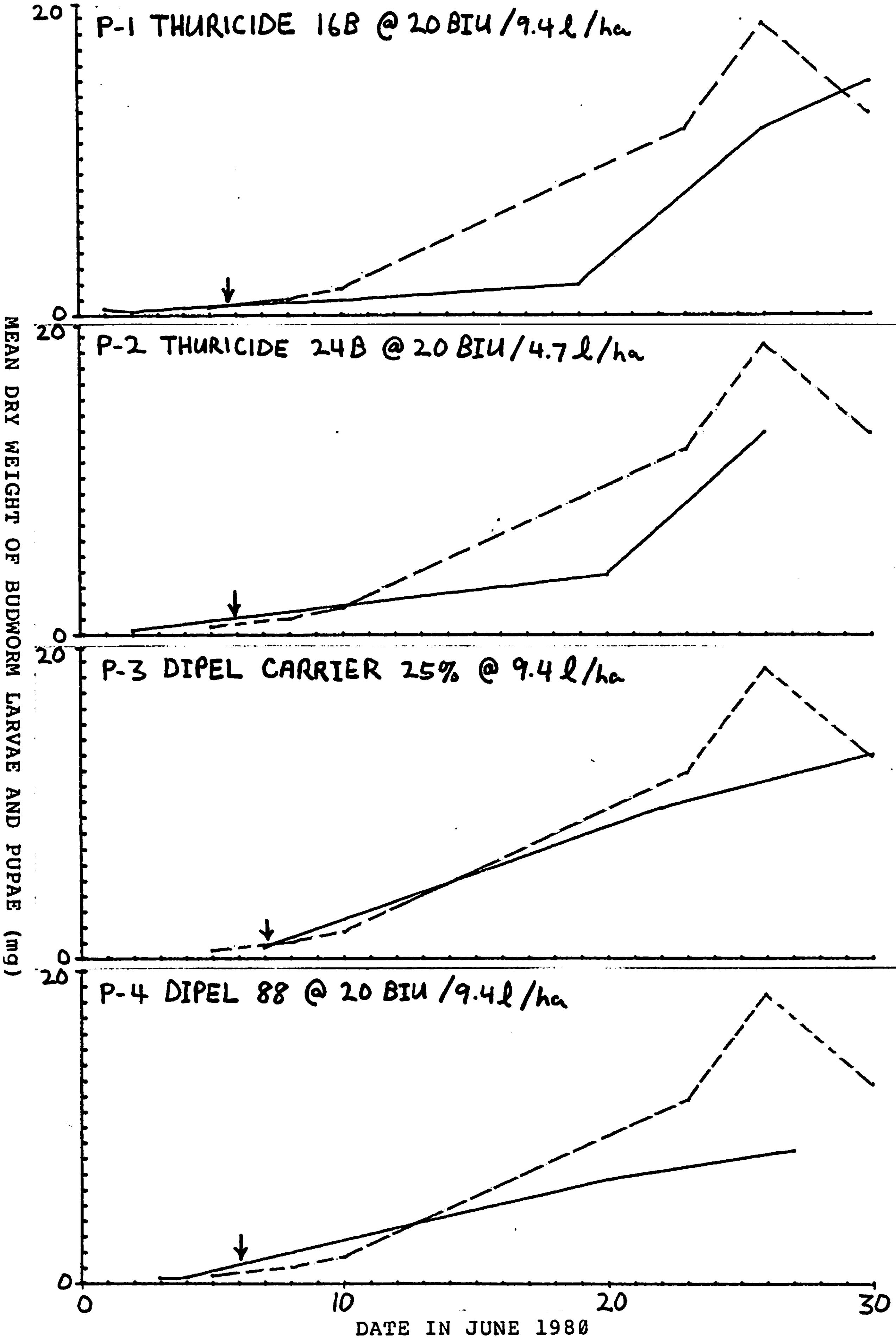


Fig 1 - Mean dry weight of budworm larvae and pupae collected from white spruce The dotted lines show the trend in the check plot Spray applications are indicated by arrows

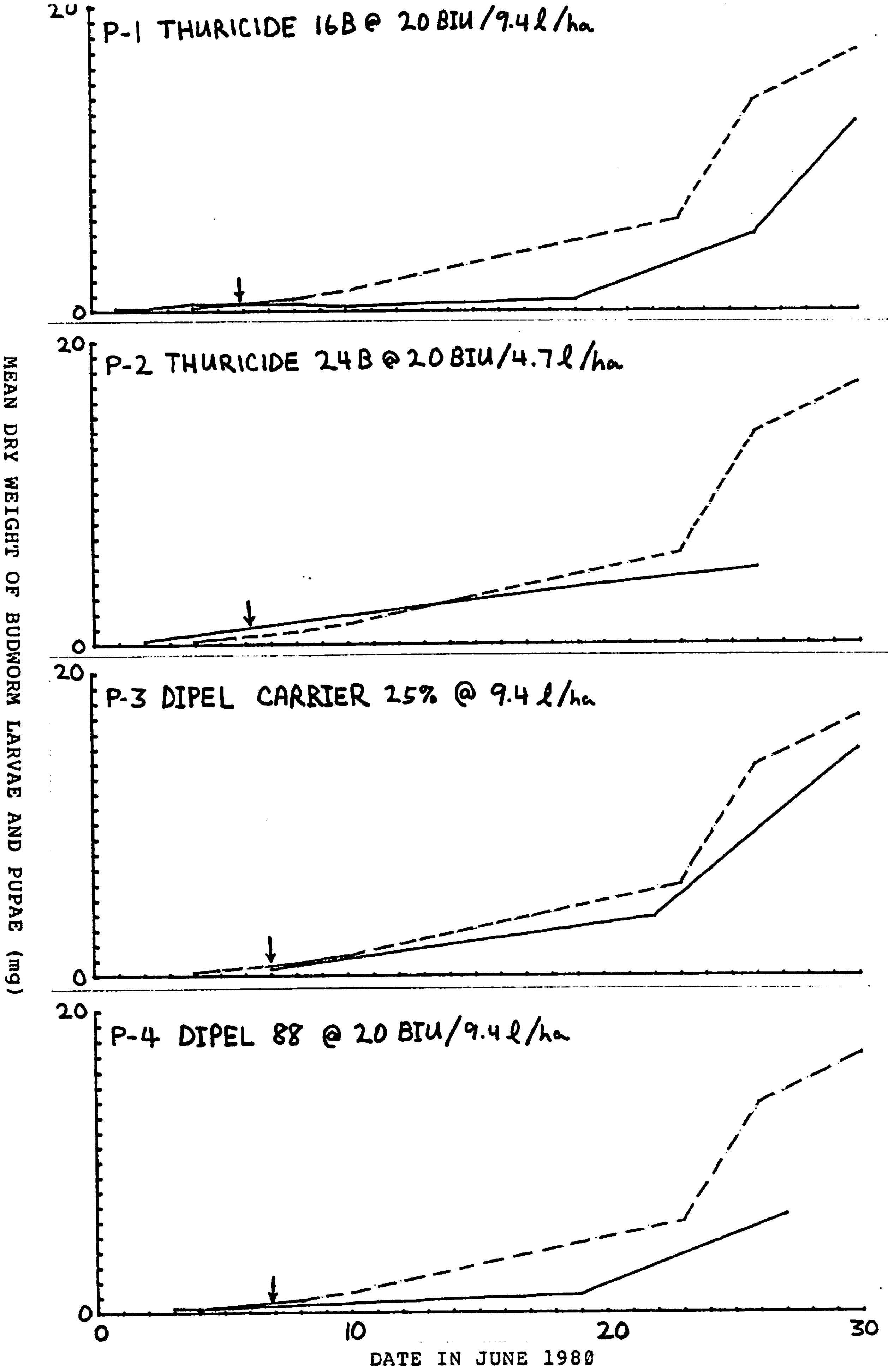


Fig 2 - Mean dry weight of budworm larvae and pupae collected from <u>balsam fir</u> The dotted lines show the trend in the check plot Spray applications are indicated by arrows

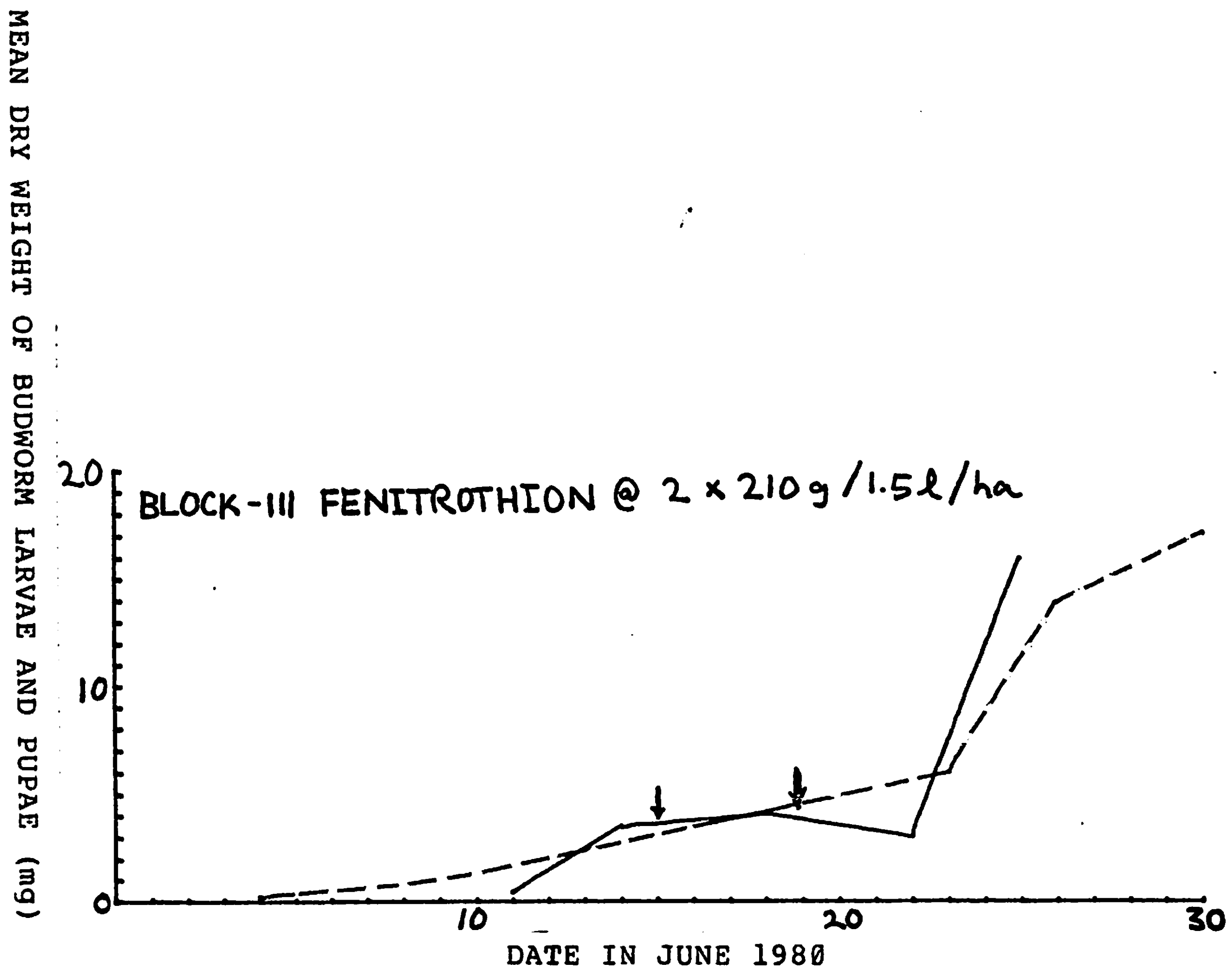
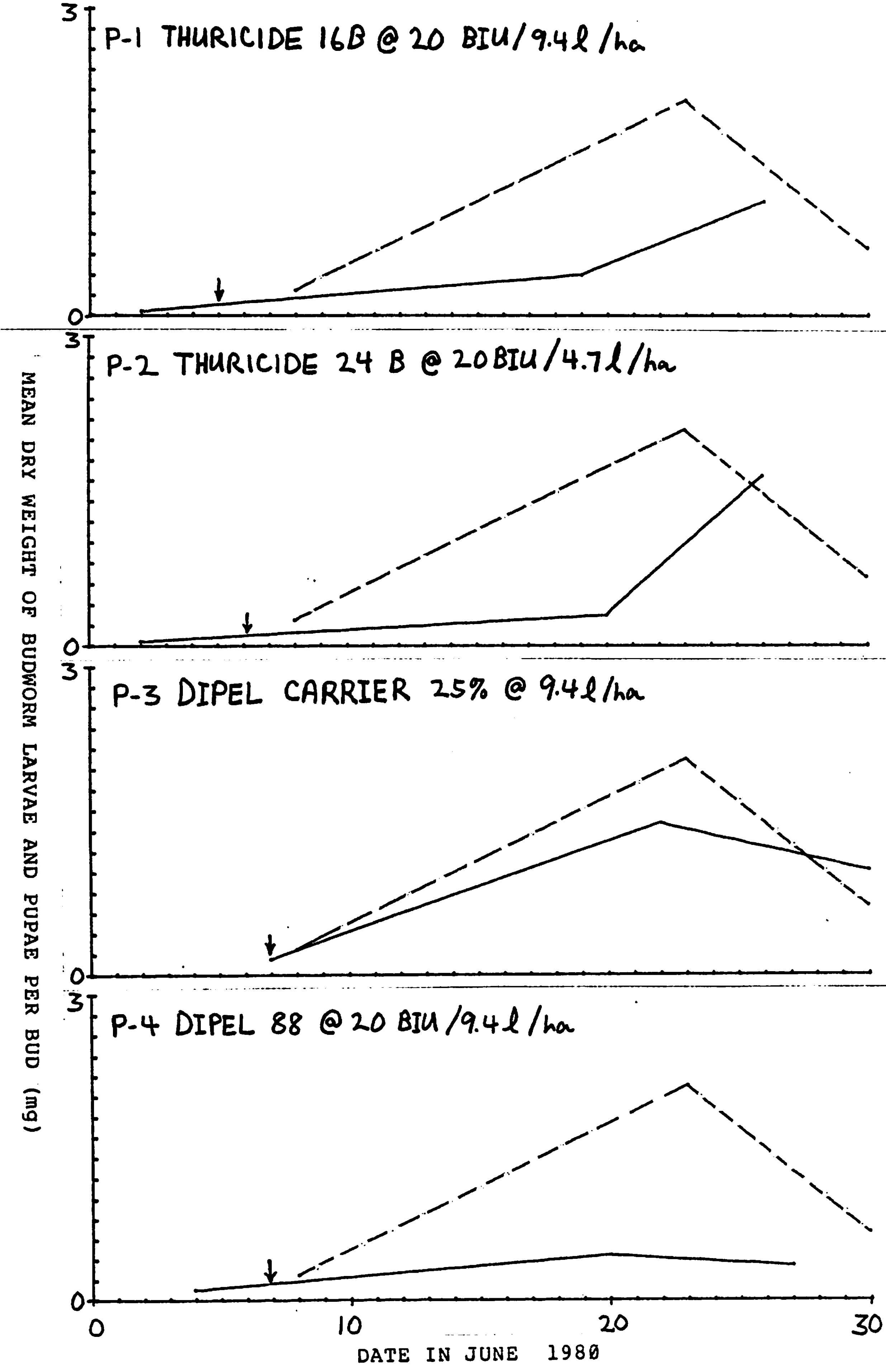


Fig 3 - Mean dry weight of budworm larvae and pupae collected from balsam fir. The dotted lines show the trend in the check plot. Spray applications are indicated by arrows.



P-1 THURICIDE 16B @ 20 BIU/9.4l/ha

P-2 THURICIDE 24 B @ 20BIU/4.7l/ha

P-3 DIPEL CARRIER 25% @ 9.4l/ha

P-4 DIPEL 88 @ 20 BIU/9.4l/ha

Fig 4 - Mean dry mass of budworm larvae and pupae per developing bud on white spruce. The dotted lines show the trend in the check plot. Spray applications are indicated by arrows.

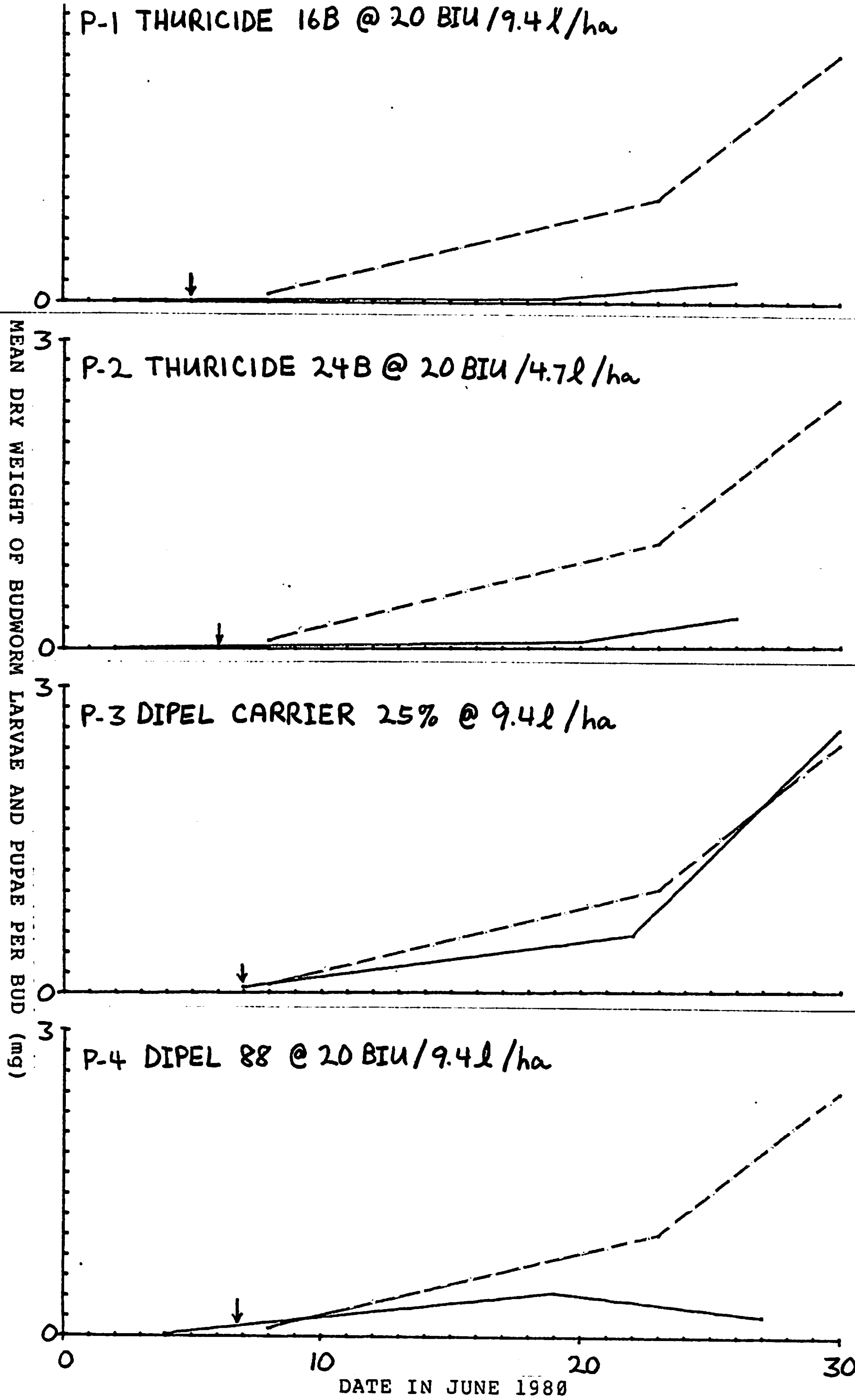


Fig 5 - Mean dry mass of budworm larvae and pupae per developing bud on balsam fir. The dotted lines show the trend in the check plot. Spray applications are indicated by arrows.

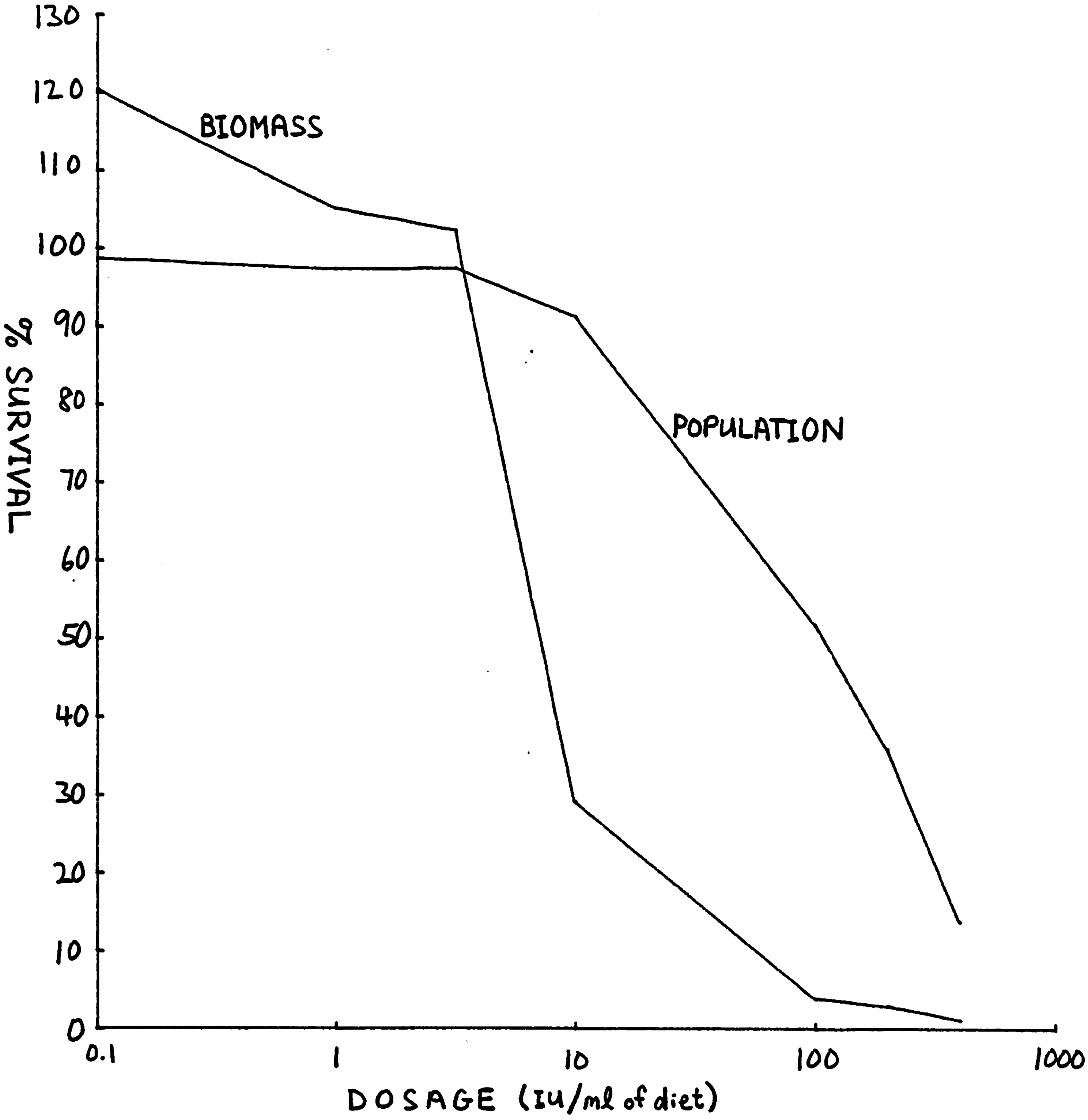


Fig. 6 Residual population and biomass of spruce budworm larvae reared for seven days on artificial diet containing several concentrations of Thuricide 16B. (Percent surviving biomass equals one hundred times the total weight of larvae surviving in the treatment group divided by the total weight of larvae surviving in the check group.)