

INHERITANCE OF RESPONSE TO PERMETHRIN BY TOBACCO BUDWORM

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Abstract

Inheritance pattern of a strain of tobacco budworm, *Heliothis virescens* (F.), following a selection regime with permethrin, showed an incomplete dominance when crossed with a reference susceptible strain. In another cross inheritance pattern of the same reference susceptible strain was equal to a non-selected field collected strain and reciprocal crosses in filial generation one. LD₅₀'s of permethrin to larvae for both reciprocal crosses of filial generation two were significantly greater than the field collected strain and both reciprocal crosses of filial generation one. Both inheritance patterns were compared with a previously published inheritance pattern with the same insecticide against different strains.

Introduction

Toxicity of the pyrethroid permethrin to larvae of various strains of the tobacco budworm, *Heliothis virescens* (F), a major pest of cotton in the United States of America, varies greatly Wolfenbarger (1998). In the Americas the inheritance of response by any insecticide to progeny of crosses of this species each generation is basically unknown.

Payne et al (1988) was the first to show data on inheritance of resistance to permethrin by strains of tobacco budworm. They determined that the inheritance pattern for this pyrethroid showed incomplete dominance and was autosomal.

Here, inheritance patterns of permethrin to larvae were determined for a non-selected field-collected strain in 1974 and a selected field-collected strain in 1983 after they were crossed with the same reference susceptible strain. These inheritance patterns were then compared to pattern of resistance by Payne et al (1988) of another selected strain when crossed with another reference susceptible strain for the same insecticide.

Materials and Methods

Technical permethrin (93%) was obtained from FMC, Inc., Princeton, NJ. Field (F) collected strain tested in 1974 was described by Wolfenbarger and Wolfenbarger (1998). Test was initiated in generation one of larvae from moths collected as larvae and reared to adults. F strain in 1983 was tested in generation 13 and 14 following selection regime with permethrin to generation 12 (Wolfenbarger 1990). Method of treatment and handling of moths were described by Wolfenbarger (1990) and Wolfenbarger and Wolfenbarger (1998). The same laboratory (L) reference strain was used in crosses for the filial generations in 1974 and 1983.

Doses of permethrin used in 1974 and 1983 were the same used by Wolfenbarger (1990) and they were diluted in one microliter of acetone. They ranged from 0.003875 to 0.5 µg/larva. LD₅₀'s, slope±standard error (S.E.), and 95% confidence intervals (CI) were determined by probit regression analysis of SAS (1988). LD₅₀'s and CIs were determined as µg/larva. LD₅₀'s were equal when they showed overlapping CIs.

Results

In 1974 the LD₅₀' of larvae of the L strain was equal to those of F strain and reciprocal crosses in the first and second filial generation (Table 1). LD₅₀'s of larvae of the second filial generation indicated a patroclosin effect as

the LD₅₀'s for larvae of the L x F was significantly greater than LD₅₀' of the F x L. Also, the LD₅₀'s of larvae of reciprocal crosses in the second filial generation were significantly greater than the same reciprocal crosses shown in the first filial generation. Slopes of F in the first generation and L X F in second filial generation were <1 while all other slopes ranged from 1-2.

In 1983 crosses of L and F strains showed an incomplete dominance (Table 2). These results followed a selection regime for 12 generations (Wolfenbarger 1990). L strain was the same used in 1974. LD₅₀' of larvae of L and F differed by 17 and 4 fold in filial generations one and two, respectively. Both were significantly different. For both filial generations LD₅₀'s of larvae of reciprocal crosses were significantly greater than L strain and significantly less than F strain. Slopes of strains and crosses ranged from 1-2 both generations.

Discussion

Payne et al (1988) showed that the LD₅₀' of larvae of the R female x S male cross in filial generation one was 0.53 µg/larva. Then they showed that the LD₅₀'s of resistant (US82) strain was 9.7 µg/larva and the reference susceptible strain was 0.03 µg/larvae. Differences in LD₅₀' of larvae between the cross and generation one by F (they used resistant) and L reference strain (they used susceptible) were 18 and 18 fold, respectively. Confidence limits of LD₅₀' in the cross in filial generation one did not overlap confidence limits of either the resistant (U548) or the reference susceptible strain. These results show an incomplete dominance inheritance pattern (Table 2) in 1983.

In 1974, 1983 and Payne et al (1988), LD₅₀'s of larvae of F in the first filial generation were 0.019, 0.17 and 9.7 µg/larva, respectively. Each LD₅₀' was significantly different from the other. In 1974, 1983 and Payne et al (1988), LD₅₀'s of larvae of L strain were 0.0062, 0.023 and 0.03 µg/larva, respectively. L strains showed equal LD₅₀'s to larvae even though they were from two different strains. Differences were 3, 7 and 323 between the F and L strain in 1974, 1983 and Payne et al (1988), respectively.

The 1974 strain shows heterogeneity for response to permethrin. But it is clear that there was a patroclosin response to permethrin by this population. Results suggest that the source of this resistance may have been from the males of the L strain. In the L strain the CI was so great that it encompassed the responses of the F strain and reciprocal crosses both generations.

In any given strain each generation there will probably be one larva which is resistant and one which is susceptible. If one or two percent of the L male moths happened to be resistant and mated more times than the susceptible males LD₅₀'s would be greater.

Results are shown here for one insecticide and crosses of strains with different responses. More homogeneity was evident in the selected strain and their crosses from 1983 and those of Payne et al (1988) than the heterogeneity shown in the L strain and crosses with 1974 F strain. In the Americas thousands of females of this Heliothine species mate with available males each day. Most females have multiple matings and mate with different males. Each mated female can produce 100+ progeny during her three to 14 d life span. The majority lay eggs 3 to 8 d during their lifetime. Both sexes can and do disperse, at least locally. This is why response pattern of progeny can be so variable. I speculate that knowledge of the inheritance pattern is needed for progeny of 80% of females of the tobacco budworm before we can fully understand how populations respond to permethrin.

References

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Table 1. Toxicity of permethrin to tobacco budworm field [F] collected and laboratory [L] reference strains and their crosses. 1974.

Number Larvae Tested	Slope±Standard Error	LD₅₀' (µg/ Larva)	95% Confidence Interval
F - Generation 1			
120	0.82±0.14	0.019	0.0080-0.037
L - Generation 1			
840	1.2±0.53	0.0062	0.0041-0.084
FXL-Generation 1			
480	1.41±0.47	0.02	0.015-0.25
LXF Generation 1			
2160	1.58±0.25	0.025	0.022-0.028
FXL-Generation 2			
480	1.36±0.14	0.065	0.053-0.079
LXF-generation 2			
2400	0.83±0.39	0.093	0.08-0.11

Table 2. Toxicity of permethrin to field [F]-collected and laboratory [L] reference strains and crosses of the tobacco budworm. 1983.

Number Larvae Tested	Slope±Standard Error	LD₅₀' (µg/ Larva)	95% Confidence Interval
F-Generation 13			
238	1.96±0.14	0.17	0.14-0.21
L-Generation 13			
644	1.4±0.11	0.023	0.0013-0.036
LXF-Generation 13			
546	1.43±0.091	0.054	0.039-0.073
FXL-Generation 13			
335	1.61±0.054	0.067	0.054-0.083
F-Generation 14			
431	1.59±0.15	0.084	0.075-0.098
L-Generation 14			
3089	1.61±0.12	0.024	0.019-0.03
LXF-Generation 14			
1819	1.93±0.19	0.06	0.048-0.074
FXL-Generation 14			
799	1.75±0.072	0.044	0.036-0.053