Residual Activity of Permethrin, Chlordimeform and Permethrin + Chlordimeform against Susceptible and Resistant Tobacco Budworm

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Abstract

Cotton was sprayed with permethrin, chlordimeform and the permethrin-chlordimeform combination to determine residual efficacy against resistant (R) and susceptible (S) populations of tobacco budworm (TBW) and reciprocal crosses of the two populations. Permethrin alone gave excellent results against susceptible tobacco budworm for the entire 7-day test period. However, against the resistant strain the highest level of mortality achieved was 40% on the 1-day post-treatment residue; results with the S:R and R:S (♂:♀) crosses were generally intermediate. Chlordimeform gave poor and erratic kill unrelated to the residue period regardless of the strain of TBW. The combination resulted in mortality similar to that of permethrin alone with the susceptible strain but generally greater than that with permethrin alone against the resistant strain. The combination resulted in high mortality in the crosses, particularly the R:S (♂:♀) cross.

Introduction

The tobacco budworm, *Heliothis virescens* (F), became difficult to control across the entire cottonbelt prior to the development of the pyrethroid insecticides, due to organophosphate and carbamate insecticide resistance (Graves et al. 1973; Harris 1972; Sparks 1981; Wolfenbarger et al. 1981). The new pyrethroids, which received emergency registration for use on cotton in 1977 and full registration in 1978, provided outstanding control of the tobacco budworm (TBW) over the entire belt. The subsequent widespread use of these materials, especially their use against practically all pests of cotton, caused concern among entomologists because of the potential for resistance development in the *Heliothis* spp., particularly the TBW. This subsequently occurred, first in Australia against *Heliothis armigera* (Hübner) (Gunning et al. 1984) and soon thereafter in the TBW in Texas (Plapp and Campanhola 1986). In Arizona, laboratory studies showed that selection pressure with permethrin against the TBW resulted in significant increases in resistance in 10 to 12 generations (Jensen et al. 1984). Chlordimeform was then shown to synergise permethrin against resistant TBW (Plapp and Campanhola 1986).

This study was conducted to determine the residual efficacy of permethrin, chlordimeform, and the combination against both resistant and susceptible populations of TBW and their reciprocal crosses.

Materials and Methods

The experiment was conducted on DPL-62 cotton at the University of Arizona Campus Agricultural Center in September, 1986. Treatments consisted of the untreated check, permethrin, (@ 0.112 kg/ha), chlordimeform (@ 0.140 kg/ha) and a combination of both at the above rates. The insecticides were

applied with a back-pack, CO_2-powered sprayer using 3 nozzles/row to deliver 187 L/ha total volume.

Plots consisted of 2 rows by 30.5m in length to provide the leaves for conducting bioassays. Half-grown leaves near the plant terminal were pulled at post-treatment intervals of 0, 1, 3, 5 and 7-day, and taken to the laboratory for the bioassays.

Treatments were replicated 10 times with a replicate consisting of a single leaf in a Petri dish with 10 neonate larvae of the appropriate strain. After larvae were placed on the leaves, the Petri dishes were grouped according to treatment and residue date and held in darkness in a rearing room at a temperature of ca 26.7°C. Mortality counts were made 24- and 48-h after placement on the leaves.

Strains of TBW developed and/or maintained in our laboratory were: 1) susceptible (S) (a laboratory strain maintained since 1965 by and obtained from the Western Biological Control Laboratory, USDA/ARS, Tucson, AZ); 2) resistant (R) (selected with permethrin continuously from the fall, 1980; colony collected from cotton in Maricopa Co., AZ); 3) S:R strain (♂:♀) and 4) R:S (♂:♀) strain.

Results and Discussion

Tables 1 through 4 show the effects of the insecticide treatments on the 4 strains of TBW for residue periods of 0 through 7-d. The relative LD_{50} values (and confidence limits) of the 4 strains of TBW used in this study were determined at or near the time when the field study was conducted. These were: susceptible, LD_{50} 0.212 μg/g (0.198-0.226); resistant, LD_{50} 8930 μg/g (7890-10,100); S♂ x R♀, 4.89 μg/g (4.50-5.32); and R♂ x S♀, LD_{50} 4.87 μg/g (3.92-5.88). Table 1 shows that the permethrin-susceptible strain responded similarly to permethrin (P) and the combination of permethrin-chlordimeform (P-C), both of which gave good control throughout the 7-d test period. Only toward the end of the test period did the combination result in significantly higher mortality. Chlordimeform (C) resulted in significantly less mortality than the P and P-C treatments but generally more than the untreated check. It was also erratic from one sample period to the next.

When treatments were bioassayed with permethrin-resistant (R) tobacco budworm (Table 2), only the P-C combination gave significantly better control than that in the untreated check, and it was more erratic and of lesser magnitude than with the susceptible (S) strain (Table 1). With the R strain, in most instances, permethrin-induced mortality was not significantly different from the check. Check mortality in the R strain was greater than that in the S strain, although not significantly so (Table 5).

Tables 3 and 4 present results of the reciprocal crosses, S:R and R:S (♂:♀), respectively. Both show relatively low check mortality, with somewhat higher mortality in the C treatment, significantly higher 30% of the time. In most cases P-induced mortality was intermediate and significantly greater than the check and C treatments, but significantly less than in the P-C treatment. Mortality caused by both P and P-C treatments was not significnatly different for the initial sample (0-day). However, for the remaining post-treatment sample periods of 1-, 3-, 5- and 7-d, mortality was significantly greater with the P-C combination than with P alone. Of interest here with both treatments was the higher mortality achieved in the R:S cross than in the S:R cross. This was not observed using the topical treatment method with similar crosses.

Tables 5 through 8 compare treatment effects among the 4 strains. Table 5 shows the check mortality, indicating greater mortality in the R strain, intermediate mortality in the S strain and least of all in both crosses - with the exception of that on the 7-d residue sample.

Table 6 shows the effect of permethrin on the 4 strains. For the most part, the greatest and least amount of mortality occurred in the S and R strains, respectively. Trends over time were: S strain,

high mortality and fairly constant over the entire test period; R strain, low and uniform mortality over time; and the reciprocal crosses, fairly high initially with a general decline over time.

Table 7 presents mortality of the 4 strains where P-C was applied. The R strain had significantly lower mortality than that of the S strain throughout the period studied. The mortality of the crosses was significantly less than or equal to that of the S strain, and greater than that of the R strain in most cases. The R:S cross again had higher mortality than the reciprocal cross, in some cases significantly higher.

Of interest in the C treatment was the effect on the S:R cross, showing generally lower mortality when compared with the R, S and R:S strains (Table 8). Mortality was variable over time for all strains.

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Table 1. Effect of permethrin, chlordimeform or the combination on permethrin-susceptible tobacco budworm[1].

	Percent mortality[2] (24- and 48-h) for indicated residue periods (day)									
	0		1		3		5		7	
Treatment	24	48	24	48	24	48	24	48	24	48
Check	1a	3a	5a	9a	1a	7a	3a	4a	0a	4a
Chlordimeform	3a	13b	19a	37b	16b	33b	1a	4a	3a	36b
Permethrin	93b	99c	91b	91c	89c	98c	73b	95b	53b	83c
Permethrin + Chlordimeform	96b	100c	96b	100c	86c	99c	92c	99b	74c	99d

[1] LD_{50} of susceptible strain with permethrin was 0.212 μg/g (0.198-0.226).
[2] Percent mortalities in each column followed by the same letter are not significantly different ($P>0.05$) (SPSS^x, ANOVA using one-way procedure).

Table 2. Effect of permethrin, chlordimeform or the combination on permethrin-resistant tobacco budworm[1].

	Percent mortality (24- and 48-h) for indicated residue periods (d)									
	0		1		3		5		7	
Treatment	24	48	24	48	24	48	24	48	24	48
Check	4a	12a	0a	12a	3a	13ab	2a	3a	3ab	13a
Chlordimeform	10a	21ab	1a	33b	9ab	27b	5a	45c	1a	29b
Permethrin	11a	29b	11b	40b	3a	11a	2a	17ab	10b	20ab
Permethrin + Chlordimeform	26b	76c	3a	79c	15b	66c	14b	24b	6ab	63c

[1] LD_{50} of permethrin-resistant strain was 8930 μg/g (7890-10,100).

Table 3. Effects of permethrin, chlordimeform or the combination on F_1 crosses of susceptible and resistant (S♂ x R♀) tobacco budworm[1].

	Percent mortality (24- and 48-h) for indicated residue periods (d)									
	0		1		3		5		7	
Treatment	24	48	24	48	24	48	24	48	24	48
Check	0a	2a	0a	4a	0a	1a	1a	5a	2a	12a
Chlordimeform	2a	2a	1a	12a	5a	8a	5a	29b	7a	20a
Permethrin	66b	72b	12a	57b	25b	43b	31b	41b	5a	22a
Permethrin + Chlordimeform	66b	84b	27b	95c	54c	83c	50c	83c	27b	56b

[1] LD_{50} of the S♂ x R♀ cross with permethrin was 4.89 μg/g (4.50-5.32).

Table 4. Effects of permethrin, chlordimeform or the combination on F_1 crosses of resistant and susceptible (R♂ x S♀) tobacco budworm[1].

	Percent mortality (24- and 48-h) for indicated residue periods (d)									
	0		1		3		5		7	
Treatment	24	48	24	48	24	48	24	48	24	48
Check	0a	2a	4a	6a	0a	1a	2a	6a	0a	28a
Chlordimeform	0a	4a	8a	30b	19b	32b	10a	24b	16a	86bc
Permethrin	76b	88b	49b	63c	29b	48c	9a	26b	15a	72b
Permethrin + Chlordimeform	76b	100b	72c	95d	90c	99d	37b	86c	61b	98c

[1] LD_{50} of the R♂ x S♀ cross with permethrin was 4.87 μg/g (3.92-5.88).

Table 5. Control mortality among 4 strains of TBW over 5 test periods.

	Percent mortality (24- and 48-h) for indicated residue periods (d)									
	0		1		3		5		7	
Strain	24	48	24	48	24	48	24	48	24	48
Susceptible	1a	3a	5b	9a	1ab	7ab	3a	4a	0a	4a
S:R (♂ + ♀)	0a	2a	0a	4a	0a	1a	1a	5a	2a	12a
R:S (♂ + ♀)	0a	2a	4ab	6a	0a	1a	2a	6a	0a	28b
Resistant	4a	12b	0a	12a	3b	13b	2a	3a	3a	13a

Table 6. Permethrin-induced mortality among 4 strains of TBW over 5 test periods.

	Percent mortality (24- and 48-h) for indicated residue periods (d)									
	0		1		3		5		7	
Strain	24	48	24	48	24	48	24	48	24	48
Susceptible	93c	99c	91c	91c	89c	98c	73c	95c	53b	83b
S:R (♂ + ♀)	66b	72b	12a	57b	25b	43b	31b	41b	5a	22a
R:S (♂ + ♀)	76bc	88bc	49b	63b	29b	48b	9a	26a	15a	72b
Resistant	11a	29a	11a	40a	3a	11a	2a	17a	10a	20a

Table 7. Permethrin + chlordimeform-induced mortality among 4 strains of TBW over 5 test periods.

	Percent mortality (24- and 48-h) for indicated residue periods (d)									
	0		1		3		5		7	
Strain	24	48	24	48	24	48	24	48	24	48
Susceptible	96c	100b	96d	100b	86c	99c	92c	99c	74b	99b
S:R (♂ + ♀)	66b	84a	27b	95b	54b	83b	50b	83b	27a	56a
R:S (♂ + ♀)	76b	100b	72c	95b	90c	99c	37b	86b	61b	98b
Resistant	26a	76a	3a	79a	15a	66a	14a	24a	6a	63a

Table 8. Chlordimeform-induced mortality among 4 strains of TBW over 5 test periods.

	Percent mortality (24- and 48-h) for indicated residue periods (d)									
	0		1		3		5		7	
Strain	24	48	24	48	24	48	24	48	24	48
Susceptible	3a	13bc	19b	37b	16b	33b	1a	4a	3a	36a
S:R (♂ + ♀)	2a	2a	1a	12a	5a	8a	5ab	29bc	7ab	20a
R:S (♂ + ♀)	0a	4ab	8ab	30ab	19b	32b	10b	24ab	16b	86b
Resistant	10a	21c	1a	33b	9ab	27b	5ab	45c	1a	29a