EFFECT OF SELECTED INSECTICIDES ON NATURAL ENEMIES IN COTTON: LABORATORY STUDIES

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Abstract

We evaluated the toxicity of several insecticides (Karate, Tracer, Steward, S-1812) to selected key natural enemies (green lacewing, *Chrysoperla rufilabris*; big-eyed bug, *Geocoris punctipes*; insidious flower bug, *Orius insidiosus*; *Trichogramma pretiosum*; *Cotesia marginiventris*) in residual assays. *Chrysoperla rufilabris* was affected very little by any of the insecticides evaluated. Karate and Tracer were generally more toxic to the natural enemies than were the other compounds, although the degree of this difference was quite variable. Steward and S-1812 exhibited good to excellent selectivity to natural enemies, although S-1812 had some toxic effects on *Trichogramma pretiosum* and *Orius insidiosus*. Tracer exhibited marginal to good selectivity, but was quite toxic to *Trichogramma pretiosum* and moderately toxic to *Cotesia marginiventris*. Tracer is currently a valuable IPM tool because of its selectivity, but does have some toxic effects on parasitoids, at least at the rate tested here. Steward and S-1812 also hold considerable promise as IPM tools as they exhibit good levels of selectivity.

Introduction

The role of natural enemies in cotton pest management has increased with the regional successes of boll weevil eradication, the widespread use of Bt-transgenic varieties, and the availability of selective insecticides. Fostering survival and population growth of natural enemy populations can provide economic benefit to growers, as natural enemies help to reduce pest populations. However, natural enemies alone are not always sufficient to restrain pest populations. Nevertheless, even when natural enemies do not provide complete pest suppression and insecticide use is unavoidable, the conservation of natural enemies can provide long-term benefits to growers. When selective pesticides are used in conjunction with natural enemies, secondary pest outbreaks are reduced, the interval between sprays is typically extended (reducing the number of sprays needed), and selection pressure for insecticide resistance is reduced (Croft 1990). The search for and use of selective insecticides is thus a worthy endeavor for enhancing the application of integrated pest management in cotton.

Although the cotton ecosystem has the potential to support a considerable diversity of natural enemies (Whitcomb and Bell 1964), several species tend to be more abundant or play more prominent roles in biological control than other species. Among these important species are *Orius insidiosus*, *Geocoris punctipes*, *Chrysoperla rufilabris*, *Cotesia marginiventris*, and *Trichogramma pretiosum*. These species can be quite important in suppressing populations of key cotton pests and in minimizing outbreaks of secondary pests (e.g., Ruberson et al. 1994). Therefore, understanding the effects of pesticides on these species is important for effectively integrating natural enemies and pesticides in cotton IPM programs.

The purpose of the described research was to evaluate toxicity of selected insecticides to key natural enemies in cotton (noted above), with the ultimate objective to determine which insecticides are suitable complements to the use of natural enemies in cotton IPM systems.

Materials and Methods

The study was conducted using field plots, with the treatments laid out in a randomized complete block design (4 replications of each of the 6 treatments). Each plot was 16 rows wide and 40 feet long. The cotton used was DPL 5415 and was planted on 5 May 1998. The insecticide treatments used were:

Steward (DuPont) low	0.045 lbs AI/A
Steward (DuPont) high	0.09 lbs AI/A
S-1812 (Valent)	0.10 lbs AI/A
Karate (Zeneca)	0.028 lbs AI/A
Tracer (Dow Agrosciences)	0.078 lbs AI/A
Untreated	

Insecticides were applied to the plots on 10 July and 30 July 1998. Insecticides were applied in 8.6 gallons of water per acre, at 60 psi, with a Hi-Cycle sprayer. Fully-exposed leaves from the upper third of the plant were collected one hour after application and were exposed to adults of:

Cotesia marginiventris	(*Cotesia* wasp; lab reared, ca. 12 generations)
Trichogramma pretiosum	(*Trichogramma* wasp; lab reared, ca. 25 generations)
Geocoris punctipes	(Big-eyed bug; field collected adults)
Orius insidiosus	(Pirate bug; purchased from IPM Labs, Locke NY)

and to larvae of:

Chrysoperla rufilabris	(green lacewing; purchased from IPM Labs, Locke NY).

Leaves were collected at three intervals: 1 hour after treatment, 24 hours after treatment, and 72 hours after

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treatment. Not all treatments or natural enemies were evaluated at all collection intervals (see attached tables).

Natural enemies were exposed to pesticide-treated leaves in petri plates or, in the case of *Chrysoperla rufilabris*, in a special grid cut from the covering of a fluorescent light fixture (designed to expose larvae to the treated surface of a leaf, but also to maintain them separately to eliminate cannibalism). Twelve replicates of each treatment were evaluated for each species. For *Cotesia marginiventris, Geocoris punctipes, Orius insidiosus*, and *Chrysoperla rufilabris* a replicate consisted of 5 individuals (male and female combined) per dish. For *Trichogramma pretiosum* a replicate consisted of 10.9 $\pm$ 2.32 parasitoids per dish.

The number of live insects was evaluated at 24 and 48 hours after introduction into the dishes (24 hr only for *T. pretiosum* due to high mortality after 24 hr). Insects were considered to be dead when they no longer moved when prodded. Analysis of data was with mixed model analysis (SAS 1996), followed by a separation of significantly different means with Fisher's LSD.

Results

Cotesia Marginiventris

Karate and Tracer adversely affected *C. marginiventris* at both 1 and 24 hours after treatment (HAT) (Table 1). Steward (at both rates) and S-1812 generally had no significant adverse effects, although the survival at the low rate of Steward did not differ significantly from that in the Karate and Tracer treatments for the 1 HAT, 24 hour group. Similarly, the Steward high rate and S-1812 did not differ significantly from Tracer in the 1 HAT, 48 hour group. Nevertheless, parasitoid survival in the Steward and S-1812 treatments were generally comparable to that observed in the control treatment.

Trichogramma Pretiosum

Survival of *T. pretiosum* in the Karate and Tracer treatments was significantly reduced relative to the control and Steward low treatments (Table 2). Survival in the S-1812 treatment also was reduced somewhat, not differing significantly from survival in the Karate and Tracer treatments in the 1 and 24 HAT groups. Parasitoid survival in the S-1812 and the high rate of Steward treatments did not differ significantly from the Karate treatment for leaves collected 24 HAT.

Chrysoperla Rufilabris

None of the insecticides tested affected survival of *C. rufilabris*, regardless of the time of collection for the treated leaves or duration of exposure to residues (Table 3).

Geocoris Punctipes

Survival of *G. punctipes* was significantly reduced by Tracer, and to a limited extent by Karate in the 1 HAT, 24 hr group (Table 4). By 48 hr, however, survival in the Karate treatment had declined further. Mortality in the 24 HAT group was highest for predators in the Karate treatment, but only after 48 hours of exposure. Generally, survival in all treatments was moderate to high.

Orius Insidiosus

Survival of *O. insidiosus* was reduced significantly in the Karate treatment, with moderate reductions in the Tracer and S-1812 treatments for the 1 HAT, 24 and 48 hr groups, and in the Karate treatment for the 24 HAT, 24 hr group (Table 5). Survival was only significantly reduced in the Karate treatment 24 HAT. Mortality in the control treatment of the 24 HAT, 48 hr group was unacceptably high, which led to the discarding of this group from analysis. No significant differences in survival were observed in the 72 HAT test among those treatments evaluated; however, the variability was quite high and may have masked some effects.

Discussion

The insecticides tested exhibited a variety of effects, and the species tested showed a range of susceptibilities. *Chrysoperla rufilabris* was affected very little by any of the insecticides evaluated. This is in contrast with the results of Elzen et al. (1998) who found that *Chrysoperla carnea* was relatively more susceptible than *Geocoris punctipes* and *Orius insidiosus* to various insecticides. In their study, they used adult lacewings, whereas we used larvae, which may account for the disparity in results. The difference also may be due to species-specific differences between *C. carnea* and *C. rufilabris*.

Trichogramma pretiosum and *Orius insidiosus* were both adversely affected by Karate and Tracer. Karate and Tracer were generally more toxic to the natural enemies than were the other compounds, although the degree of this difference was quite variable. Tracer was considerably more toxic to both of the parasitoids than it was to predators, although there was also some toxicity to both *Geocoris punctipes* and *Orius insidiosus* by this insecticide. Again, this contrasts with the results of Elzen et al. (1998) who found no effect of Tracer on either *Geocoris punctipes* or *Orius insidiosus*.

Steward and S-1812 exhibited good to excellent selectivity to all of the natural enemies tested, although there were some indications of adverse effects of S-1812 on *Orius insidiosus*, *Trichogramma pretiosum*, and *Cotesia marginiventris*. Tillman et al. (1998) found that Steward topically applied effected little toxicity in several natural enemies (*Cardiochiles nigriceps, Microplitis croceipes, Cotesia marginiventris, Geocoris punctipes*, and *Coccinella septempunctata*), except at very high rates, where *G. punctipes*, *C. marginiventris*, and *C. septempunctata* were adversely affected. When residues of Steward on cotton leaves were evaluated, Tillman et al. (1998) observed no adverse effects on any of the natural enemies screened.

Tracer exhibited marginal to good selectivity to all tested species except *Trichogramma pretiosum*. This is commensurate with other studies that have shown some adverse effects of Tracer on hymenopteran parasitoids (Murray and Lloyd 1997). Although in a few cases Tracer reduced predator survival in our study, the mortality was generally not substantial. Tracer is known to be a valuable IPM tool because of its selectivity. The value of this selectivity has been demonstrated since this insecticide has become commercially available. Based on these and other results, Steward and S-1812, like Tracer, hold considerable promise as IPM tools as they exhibit good levels of selectivity.

It is important to point out that although toxicity effects are relevant to understanding how pesticides and natural enemies may complement one another, the full impact of pesticides on natural enemies in the field is dependent on the cumulative effects of the pesticides on natural enemy populations (e.g., Stark and Wennergren 1995). These effects may be expressed as mortality, reproductive change and population growth, altered feeding/foraging behavior, and reduced longevity, among others (Croft 1990). Although toxicity studies of natural enemies and pesticides are valuable, it is even more important to obtain data from prolonged (e.g., full season) field studies.

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Table 1. Effects of selected insecticides on % survival of *Cotesia marginiventris* (24-h and 48-h exposure to field-treated leaves). Leaves were collected 1 and 24 hours after treatment (HAT). Values in columns within HAT's followed by the same letter are not significantly different (p <0.01; LSD).

1 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	95.0 ± 9.26 A	90.0 ± 10.69 A
Karate	0.028	74.6 ± 17.64 B	34.6 ± 20.05 C
Tracer	0.078	77.3 ± 32.28 B	57.6 ± 31.90 BC
Steward	0.045	83.3 ± 26.58 AB	83.3 ± 26.58 A
Steward	0.09	98.3 ± 5.77 A	81.7 ± 19.92 AB
S-1812	0.10	90.0 ± 15.95 A	66.7 ± 24.62 AB

24 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	100.0 ± 0.00 A	98.3 ± 5.77 A
Karate	0.028	48.3 ± 23.87 B	28.3 ± 27.58 B
Tracer	0.078	31.7 ± 19.92 B	18.3 ± 26.23 B
Steward	0.045	100.0 ± 0.00 A	95.0 ± 12.43 A
Steward	0.09	93.3 ± 13.03 A	88.3 ± 15.86 A
S-1812	0.10	95.0 ± 9.05 A	93.3 ± 13.03 A

[1]Rates are expressed in lbs active ingredient applied per acre.

Table 2. Effects of selected insecticides on % survival of *Trichogramma pretiosum* (24-h and 48-h exposure to field-treated leaves). Leaves were collected 1 and 24 hours after treatment (HAT). Values in columns within HAT's followed by the same letter are not significantly different (p <0.01; LSD).

1 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	91.7 ± 7.90 A	NA
Karate	0.028	25.0 ± 25.92 B	NA
Tracer	0.078	14.3 ± 17.12 B	NA
Steward	0.045	77.4 ± 20.93 A	NA
Steward	0.09	87.0 ± 13.19 A	NA
S-1812	0.10	55.2 ± 34.23 AB	NA

24 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	95.2 ± 9.47 A	NA
Karate	0.028	25.6 ± 32.07 BC	NA
Tracer	0.078	5.34 ± 10.64 C	NA
Steward	0.045	80.3 ± 13.55 A	NA
Steward	0.09	60.1 ± 37.95 AB	NA
S-1812	0.10	60.9 ± 35.26 AB	NA

[1]Rates are expressed in lbs active ingredient applied per acre.

Table 3. Effects of selected insecticides on % survival of *Chrysoperla rufilabris* (24-h and 48-h exposure to field-treated leaves). Leaves were collected 1, 24, and 72 hours after treatment (HAT). Values in columns within HAT's followed by the same letter are not significantly different (p <0.01; LSD).

1 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	100.0 ± 0.00 A	96.3 ± 8.82 A
Karate	0.028	95.0 ± 9.04 A	80.8 ± 21.89 A
Tracer	0.078	98.3 ± 5.77 A	90.8 ± 14.07 A
Steward	0.045	100.0 ± 0.00 A	87.1 ± 26.34 A
Steward	0.09	98.3 ± 5.77 A	93.3 ± 9.84 A
S-1812	0.10	96.7 ± 7.78 A	87.7 ± 17.03 A

24 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	96.3 ± 8.83 A	87.8 ± 18.98 A
Karate	0.028	95.8 ± 9.71 A	80.8 ± 21.89 A
Tracer	0.078	98.3 ± 5.77 A	93.3 ± 10.33 A
Steward	0.045	95.6 ± 10.68 A	85.4 ± 20.14 A
Steward	0.09	100.0 ± 0.00 A	92.5 ± 11.72 A
S-1812	0.10	98.3 ± 5.77 A	90.0 ± 16.73 A

72 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	98.3 ± 5.77 A	98.3 ± 5.77 A
Karate	0.028	98.3 ± 5.77 A	96.7 ± 7.78 A
Tracer	0.078	100.0 ± 0.00 A	100.0 ± 0.00 A
Steward	0.045	NA	NA
Steward	0.09	NA	NA
S-1812	0.10	100.0 ± 0.00 A	100.0 ± 0.00 A

[1]Rates are expressed in lbs active ingredient applied per acre.

Table 4. Effects of selected insecticides on % survival of *Geocoris punctipes* (24-h and 48-h exposure to field-treated leaves). Leaves were collected 1, 24, and 72 hours after treatment (HAT). Values in columns within HAT's followed by the same letter are not significantly different (p <0.01; LSD).

1 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	100.0 ± 0.00 A	100.0 ± 0.00 A
Karate	0.028	78.3 ± 23.29 AB	36.7 ± 33.93 C
Tracer	0.078	68.3 ± 40.41 B	52.5 ± 46.1 BC
Steward	0.045	95.0 ± 9.05 A	79.2 ± 25.03 ABC
Steward	0.09	96.7 ± 7.78 A	85.8 ± 17.30 AB
S-1812	0.10	90.0 ± 15.95 A	70.0 ± 24.86 AB

24 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	98.3 ± 5.77 A	93.3 ± 13.03 A
Karate	0.028	91.7 ± 15.86 A	46.7 ± 24.62 B
Tracer	0.078	90.0 ± 20.00 A	78.6 ± 26.26 AB
Steward	0.045	100.0 ± 0.00 A	98.3 ± 5.77 A
Steward	0.09	98.3 ± 5.77 A	96.7 ± 7.78 A
S-1812	0.10	100.0 ± 0.00 A	96.7 ± 7.78 A

72 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	100.0 ± 0.00 A	98.3 ± 5.77 A
Karate	0.028	77.1 ± 13.39 A	62.9 ± 22.51 A
Tracer	0.078	84.0 ± 8.94 A	60.0 ± 24.49 A
Steward	0.045	NA	NA
Steward	0.09	NA	NA
S-1812	0.10	86.7 ± 32.66 A	60.0 ± 48.89 A

[1]Rates are expressed in lbs active ingredient applied per acre.

Table 5. Effects of selected insecticides on % survival of *Orius insidiosus* (24-h and 48-h exposure to field-treated leaves). Leaves were collected 1, 24, and 72 hours after treatment (HAT). Values in columns within HAT's followed by the same letter are not significantly different (p <0.01; LSD).

1 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	96.7 ± 7.78 A	93.3 ± 9.85 A
Karate	0.028	13.3 ± 19.69B	3.33 ± 7.78 B
Tracer	0.078	51.7 ± 50.78 AB	51.7 ± 50.78 AB
Steward	0.045	85.0 ± 20.67 A	63.1 ± 33.89 AB
Steward	0.09	93.3 ± 9.85 A	83.0 ± 20.27 AB
S-1812	0.10	56.1 ± 40.16 AB	45.0 ± 44.42 AB

24 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	88.3 ± 15.86 A	NA[2]
Karate	0.028	30.4 ± 29.88 B	NA[2]
Tracer	0.078	70.0 ± 39.31 AB	NA[2]
Steward	0.045	87.9 ± 23.50 A	NA[2]
Steward	0.09	91.7 ± 13.37 A	NA[2]
S-1812	0.10	74.2 ± 30.29 AB	NA[2]

72 HAT			
Insecticide	Rate[1]	24 hr	48 hr
Untreated	NA	97.2 ± 8.33 A	87.8 ± 15.43 A
Karate	0.028	45.0 ± 34.25 A	38.3 ± 37.62 A
Tracer	0.078	55.0 ± 47.58 A	53.3 ± 46.19 A
Steward	0.045	NA	NA
Steward	0.09	NA	NA
S-1812	0.10	NA	NA

[1]Rates are expressed in lbs active ingredient applied per acre.
[2]Control mortality in this group was unacceptably high; thus, these data were discarded.